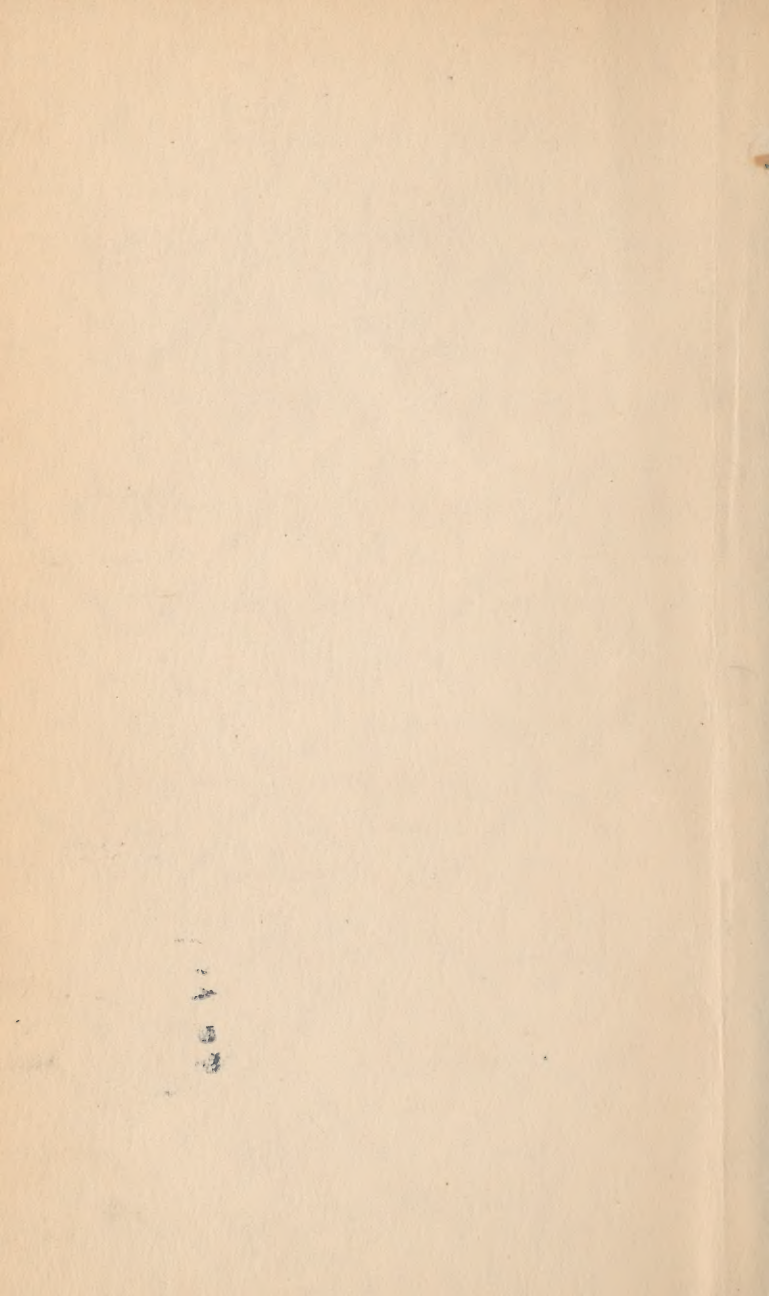


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U.S. WAR DEPT.

BASIC FIELD MANUAL. DESERT OPERATIONS.
FM 31-25.





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WAR DEPARTMENT

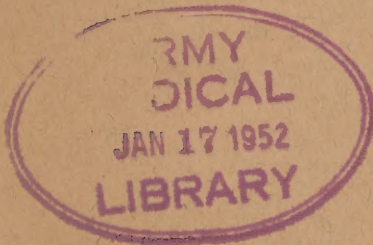
BASIC FIELD MANUAL



DESERT OPERATIONS

March 14, 1942

NATIONAL RESEARCH COUNCIL
DIV. OF MED. SCIENCES
Office of Medical Information



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FM 31-25

BASIC FIELD MANUAL



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WAR DEPARTMENT,
WASHINGTON, March 14, 1942.

FM 31-25, Desert Operations, is published for the information and guidance of all concerned. Its provisions should be studied in conjunction with FM 100-5.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

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RESTRICTED
BASIC FIELD MANUAL
DESERT OPERATIONS

SECTION I

GENERAL

■ 1. GENERAL.—*a.* In desert warfare certain general conditions will be encountered which will profoundly affect military operations. Special equipment, special training and conditioning, and a high degree of self-discipline are essential to successful desert operations.

b. This manual has been compiled from a study of MID reports, interviews with observers, and all other sources of information available at the time of preparation. It is not a complete treatment of the subject of desert warfare since none of our troops have, up to the present, had experience in desert operations. It is intended to suggest the more important factors and conditions which must be considered in preparation for operations in the desert. The basic tactical doctrine set forth in FM 100-5 is applicable to the conduct of operations in all types of terrain. While the information included in this manual is based primarily on the experience in the Western Desert in Africa, it is believed that it is applicable generally to all deserts.

■ 2. CHARACTERISTICS OF DESERTS (figs. 1 to 4, incl.).—All deserts, regardless of latitude, have certain characteristics in common—lack of water, absence of vegetation, large areas of sand, extreme temperature ranges, and brilliant sunlight. The terrain in deserts is not necessarily flat and level. There are hills and valleys, mountains and sand dunes, rocks, shale, and salt marshes, as well as great expanses of sand. Erosion in rocky areas produces effects similar to the rim-rock in some of our Middle Western States. These may pre-



FIGURE 1.—Trans-Jordan Desert.



FIGURE 2.—Trans-Jordan Desert camp.

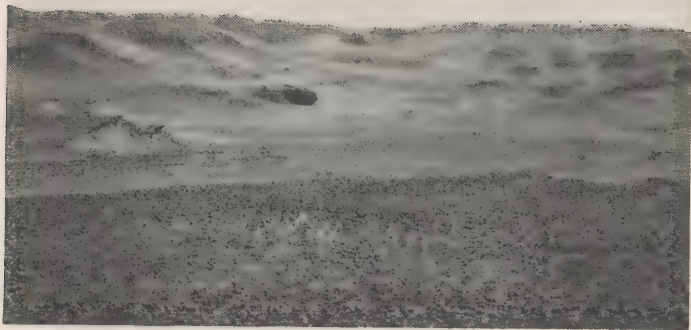


FIGURE 3.—Egypt, Western Desert.



FIGURE 4.—Libyan Desert.



FIGURE 5.—Escarpment in Western Desert, Egypt.

sent obstacles which are impassable to vehicles of any sort; the escarpment near the seacoast in Egypt and Libya, several hundred feet high at points, is such an obstacle. (See fig. 5.)

■ 3. TRAVEL IN DESERT.—There are few roads and trails in the desert. Those that exist connect villages and oases. Travel is not, however, confined to roads and trails but is usually possible in any general direction. The types of terrain vary and present only local difficulties to movement. In the Sahara are found sand dunes, sand hillocks, stretches of deep, soft sand, rock-strewn areas, and salt marshes. All are passable for a man on foot and for the domesticated animals of the region—camels, horses, and donkeys. Wheeled vehicles have traversed all parts of the African desert and track-laying vehicles have been used in many areas.

■ 4. SAND DUNES (figs. 6 and 7).—*a*. These are great ridges of deep, soft sand. In the Sahara they are found particularly in the Sand Sea. Dunes usually stretch along roughly



FIGURE 6.—Sand dunes in Western Desert, Egypt.

parallel to the direction of the prevailing winds. Since many dunes are so high and steep that they must be detoured, a route through an area of sand dunes is long and tortuous. There are few “shifting” dunes of soft sand in Africa—almost none in the Sand Sea. The surface of a sand dune is usually packed by the wind to a depth of about 2 inches. This wind-packed crust will support considerable distributed weight normal to its surface, but since the sand grains have little mutual cohesion the crust will break under driving or braking thrust.

b. Successful vehicle operation in sand dunes is possible with proper equipment if drivers are given sufficient training. The fundamental governing successful driving in this terrain is to reduce unit pressure and driving thrust to a minimum. Tires should be oversize and operated at low pressure. They should have a smooth tread. (See par. 22.) Snow or other corrugated treads will bite into the crust, break it, and dig into the soft sand underneath. Experienced drivers, given suitable training, will develop an eye for the



FIGURE 7.—Sand dune in Sand Sea.

ground. Such drivers, by intelligent use of momentum, careful pre-selection of gears, and gradual application of throttle and of brakes will be able to traverse sand dune areas. Large dunes must be detoured and the smaller ones rushed. Each vehicle must avoid the tracks of preceding ones. Soft spots are frequent but can be avoided. Frequently a reconnaissance on foot will be necessary. Difficult as such driving is, daily mileages of 100 to 150 miles during daylight have been made over extended periods of time by experienced drivers with fully loaded, 4 x 2, 11½-ton trucks.

c. Up to the present, track-laying vehicles have not been used in military operations in sand dunes. It is believed that such vehicles, up to about 13 tons in weight, equipped to shift gears easily at speed, should be able to negotiate this type of terrain after drivers have been carefully trained.

■ 5. SAND HILLOCKS.—In parts of the desert, shrubs have served as windbreaks for wind-borne sand, causing the sand to build mounds about the base of the shrubs. These mounds are from a few inches to several feet in height and are usually so spaced that motor travel through such an area

is difficult or impossible, particularly for heavy supply columns. Areas of sand hillocks vary from a few acres to many miles in extent. If such areas cannot be detoured, suitable trails may be made with a road grader, bulldozer, or heavy drag towed behind a tractor or truck. Several miles of passable road can be made per hour by this method.

■ 6. DEEP SAND (figs. 8 and 9).—Stretches of deep, soft sand may be encountered anywhere in the desert. They are particularly prevalent in areas where there has been much travel. The sand is seldom deep enough to prevent the passage of either wheeled or track-laying vehicles, although wheeled vehicles may frequently get stuck. (See par. 25.)

■ 7. BOULDER-STREWN AREAS (fig. 10).—There are many miles of such areas in the African deserts. The boulders are limestone, sandstone, or volcanic rock. These rocks are usually not large but are hard and sharp and are so numerous that it is impossible to avoid any but the largest. Such areas may be traversed by all types of military vehicles, but ex-



FIGURE 8.—Pebbly desert and soft sand, Libyan Desert.

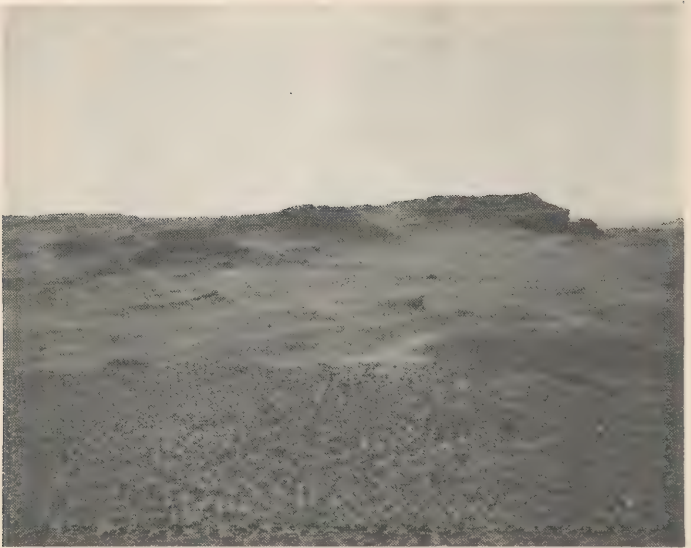


FIGURE 9.—Rocks, soft sand, and limestone, Libyan Desert.



FIGURE 10.—Boulder-strewn terrain, Libyan Desert.

cessive tire wear and track and spring breakage, as well as unusual wear and tear on vehicles due to jolting, must be expected.

■ 8. SALT MARSHES (fig. 11).—These are usually dry lake or stream beds and may be encountered along the coast or inland in depressions. They are generally impassable when moist. When dry they may be traversed by light vehicles if the surface is sandy and the route is reconnoitered on foot. When the surface is predominantly powdery silt, they are impassable. Roads may be made across dry silt beds by rolling or packing the silt after it is moistened with brackish or salt water as a binder, or by sand fill. Except under unusual conditions salt marshes should be detoured.

■ 9. WATER.—*a.* Adequate water supply is the problem which dominates all others in desert operations. Excessive heat and lack of moisture in the atmosphere increase water consumption in an area in which water is almost nonexistent. In the Sahara there are no rivers or stagnant bodies of water. Except close to the seacoast, subsoil water is rarely



FIGURE 11.—Salt marsh in Western Desert, Egypt.

present. The water in existing oases is scanty, usually infected, mostly filthy, and at best disagreeable to the taste. Troop operation is dependent on the water-carrying capacity of organic or specially allotted equipment, the training and discipline of the personnel in water consumption, and the possibility of replenishment of water supplies from bases where an adequate quantity is available. (See par. 16.)

b. Troops from a temperate climate must be specially conditioned for desert operations. They require a sufficient period of training to accustom themselves to the heat and to develop the ability to get along on a minimum quantity of water. High temperatures are normal in the desert and the loss of body moisture through perspiration is high.

■ 10. TEMPERATURE.—The daily temperature range in the desert is excessive during all seasons. The average temperature in the hottest part of the day is well over 100° F. In the summer season the maximum temperature is so great (120° to 130° F. in the shade) that it makes very difficult extended operations by large bodies of troops. The daily temperature variation is so great, even during this season, that overcoats or heavy sweaters and blankets are often required at night. Specially trained and equipped small patrols can operate freely over wide areas during any period. The winter season, roughly November to March, inclusive, in the Libyan Desert, is the best period for large scale military operations. Nights are cold during this period, the temperature oftentimes dropping below the freezing point. Warm clothing and three to five blankets per man should be provided for the troops (see par. 18).

■ 11. WIND.—Wind conditions vary in the desert as in other terrain. In the Libyan Desert light breezes, usually from the north or west, are common during the day and after sunset. Storms of hurricane velocity are not infrequent during the day and night throughout the year. Such storms carry large quantities of dust and sand and are frequently accompanied by rapid changes in temperature—a sudden drop in the winter, a painful rise in the summer. Observation and movement may be extremely difficult during a heavy sandstorm.

■ 12. VISIBILITY.—a. Despite the lack of concealment, the clear skies, and the vast, relatively flat and featureless

stretches of ground, visibility as it affects terrestrial observation is not usually good in the desert.

b. The position of the sun has considerable effect on observation. When the sun is behind an observer he sees objects plainly, without shadow, whereas an observer looking in the opposite direction is not only handicapped by the glare of the sun itself and its reflection from the ground, but sees all objects in shadow. In the early morning observation is better from east to west than from west to east. At midday it is much more difficult to observe into the sun, that is, to the south, than away from it. In the afternoon and evening the observer looking from west to east has the best observation. During winter, when the sun is lower on the horizon throughout the day than it is in summer, these effects are accentuated. Forces now operating in the desert have timed their attacks, whenever possible, so as to have the sun at their backs.

c. Visibility is so poor during dust storms that air observation of ground forces is impossible, and terrestrial observation is greatly reduced, sometimes to less than 100 yards. These storms, when they were not too heavy, have been used to facilitate surprise in carrying out approach marches over previously reconnoitered routes, in making surprise attacks on lines of communication and supply installations, and in raids by small groups on defensive positions. They have not been used to gain surprise for large scale attacks because they make control and maneuver extremely difficult and render close artillery or air support impossible.

d. Mirage has an adverse effect on visibility and ground observation. It is most frequent in the summer, but it is very difficult to determine under what conditions it will occur and what form it will take. Mirage is seen by an observer who is facing the sun. It is evident on a wide arc which increases as the sun becomes higher in the sky, both according to the season of the year and the hour of the day. Its effect generally is to magnify objects, particularly the vertical dimension. It makes recognition of vehicles very difficult. Under certain circumstances it may give protection from view at distances as close as 500 yards.

e. Wind, through its effect on dust or smoke, whether created by vehicles or shell fire, will affect visibility. Vehicles

attacking down wind risk being blinded by their own dust. When withdrawing from action, movement into the wind, when possible, affords concealment by the dust created. An attack supported by artillery should not be made from the direction into which the dust is being blown. A movement concealed from hostile observers by an intervening crest may be disclosed by the dust raised, even when the vehicles cannot be seen.

f. Moonlight is normally very bright in the desert. Troop movements at night, except during the dark of the moon or during dust storms, are readily observed by both ground and air observers. During the dark of the moon, night observation is impossible without the use of flares.

■ 13. VEGETATION.—There is almost a complete lack of vegetation in deserts. Some growth, usually palms, will be found at oases, and in certain areas thorn trees and small tufts of grass grow. In general there will be no natural growth for shade, shelter, or concealment from observation. In addition to the discomfort caused by the lack of protection usually afforded by natural growths, there is a psychological reaction in individuals who are accustomed to more normal terrain. This reaction produces a feeling of nakedness, exposure to all observation, which, in many individuals, results in undue apprehension of the dangers of enemy action. Troops will require a period of time to overcome this feeling.

SECTION II

FOOD, CLOTHING, AND INDIVIDUAL EQUIPMENT

■ 14. Food.—*a.* No dependence can be placed on local sources for the supply of food for troops engaged in desert operations. Even small long-distance patrols should be supplied with sufficient food to cover the period of their operations as no assurance can be had that any food can be obtained at oases.

b. Normal field and emergency rations are suitable for the nourishment of troops in the desert. However, consideration must be given to the fact that it will usually be impossible to conduct unit messes in the field, hence *cooking will have to be done by individuals and small units,*

usually the occupants of one vehicle. Rations should be so packed that they can readily be broken down for issue to individuals and small groups. They should be of a type that enables individual preparation with a minimum amount of water. This indicates the necessity for a high proportion of canned goods.

■ 15. COOKING.—*a.* Unit messing will be impossible, except in rear areas, and then only when the threat of low-flying or dive-bombing air attacks is negligible. *Under normal conditions meals must be prepared by individuals and small units.* Every vehicle should be equipped with a small stove, using gasoline or canned heat as fuel, adequate for the preparation of the food for the personnel transported in the vehicle.

b. When food is prepared in a unit mess, care should be taken to use salt sparingly, and the use of condiments which induce thirst should be avoided. Food prepared by small units should be limited to articles which can be heated in cans as the water used in cooking must come from the individual water rations. Water used for heating cans of food can then be used in the preparation of hot beverages.

■ 16. WATER.—*a.* The importance of water cannot be over-emphasized in desert operations. In training troops it must be made clear to each individual the vital part which water supply will play in the success of the operations. *Restricted water consumption must become a habit.* Training must condition troops to live on a limited water ration and must develop such self-discipline in the use of water as will assure the maintenance of combat efficiency on the limited water supply available. Rapid drinking during the day must be avoided as nearly all the water thus consumed is quickly thrown off in excessive perspiration and thus wasted. The first cravings for water are lessened by moistening the mouth and throat. Small sips from the canteen will accomplish this. All issues of water to individuals should be made by noncommissioned officers upon the order of an officer; and no water should be taken from water supply cans except under supervision at regular issue periods.

b. Troops must become accustomed to drinking water in which salt has been dissolved. Many of the sources of water

supply in the desert furnish water with a relatively high degree of salinity. The addition of salt to water will also help make up for the high loss of body salts caused by excessive perspiration. Salt tablets should be issued for this purpose when possible. Hot sugared tea has been found to be beneficial for troops in the desert and reduces thirst. Smoking, particularly during the day, increases the desire for water and must be avoided.

c. It has been found in the Western Desert in Africa that a ration of $1\frac{1}{5}$ U. S. gallons of water per man per day will be sufficient for extended operations by trained troops. (See par 9.) This ration is for all purposes: drinking, cooking, washing, shaving, and brushing teeth. Troops on this ration cannot bathe but are limited to an occasional damp rubdown. The minimum ration for the above purposes is three-quarters U. S. gallon per man per day; however, individual efficiency will start to decrease after about 3 days on this minimum ration. In an emergency, men conditioned to desert conditions can operate for as long as 5 days on a quart of water per man per day, if traveling is done at night and they can find shade during daylight hours. On such a ration combat efficiency will be seriously lowered.

■ 17. RECEPTACLES FOR WATER AND FOOD.—a. The water and food rations for all of the occupants of a vehicle should be carried on the vehicle. Water is best carried in tins of from 2- to 4-gallon capacity. Larger capacity tins involve the risk of a loss of all water in the event of a leak. The water container should be provided with a screw top, fastened to the can by a chain. A rubber washer should be used with this top, as leather washers will foul the water. To prevent rusting, water cans should be galvanized or have an interior coating of paraffin wax with a high melting point. Every vehicle should be provided with at least one funnel to prevent wastage in issuing water rations.

b. If possible, vehicular racks should be provided for water and ration containers. These should be readily accessible to permit rapid unloading in the event the vehicle must be abandoned. When such racks are not built on the vehicle, wooden cases must be provided to protect water cans and rations. No case should contain more than two water cans

or 1 day's rations for the occupants of the vehicle. A special soldering iron is necessary for repairing leaks in water cans. Water containers should be so loaded that they are easily inspected for leakage. A large fixed tank is unsuitable for carrying water rations. To the danger of loss of all water in the event of an injury to the container is added the difficulty of locating and repairing leaks and of removing the collection of sludge and other deposits that rapidly accumulate in the bottom. In addition, the tank does not lend itself to rapid removal of the water from the vehicle which will often be necessary in emergencies.

■ 18. CLOTHING.—*a.* The present authorized clothing, both summer and winter, is suitable for desert operations. Consideration should be given to providing special uniform for summer use. Both British and German troops now operating in the desert are equipped with a special tropical uniform for summer wear. The principal characteristics are the lightweight material, open-necked short-sleeved shirts, shorts, and a wool half stocking. This uniform allows a free circulation of air around the body, has no ill effects on the health of troops, and does not result in excessive sunburn; the troops like it, and the British Medical Service approves of it. It does expose large areas to attack by sand flies. Because of the wide temperature range and the cool nights some sort of woolen garment is needed for wear at night during the hot season. Woolen uniforms and some type of overcoat are necessary for winter operations in the desert, as during this period the weather is generally cold, raw, and disagreeable. A woolen band should be worn over the stomach, particularly in the summer, to prevent stomach chills. The hotter the day the more necessary is this protection.

b. Various types of headgear for wear when not in combat are being used by desert troops at the present time. All have two necessary characteristics: provision of air space and a shield for the eyes. Sun helmets afford excellent protection during the summer season but deteriorate rapidly because of hard use. Hats similar to the campaign hat are used by some troops and afford excellent protection against the sun. Many individuals wear a garrison cap which provides sufficient air space and shields the eyes. The field cap, lacking

air space and visor, is unsuitable for desert wear. The steel helmet is worn during combat.

c. Special individual equipment which will add to comfort and efficiency are goggles, respirators, sun glasses, neck cloth, nose cloth, and fly switches. Goggles and dust respirators are a necessity for all vehicle drivers, and will add to the individual comfort of others, particularly during sandstorms. Good sun glasses are most desirable for all individuals and must be provided for antiaircraft and antitank gun crews and lookouts. The Arabs, as a result of centuries of desert life, wear a cloth to protect the back of the neck from the sun's rays and a cloth over the nose to protect the lungs from sand and dust during storms. Such cloths are not used by troops now operating in the African desert. They should be considered in equipping troops for desert operations. Sand flies are an always prevalent pest in the desert and undue exposure to them frequently results in sand fly fever. The use of horse-tail fly switches is almost universal among British desert forces.

SECTION III

TRANSPORTATION

■ 19. GENERAL.—Movement of troops on foot over any considerable distance is not practicable for military operations in the desert. The great distances involved, the lack of concealment, the difficult ground surfaces, and the excessive water consumption produced by the exertion of marching limit movement on foot to that which is necessary for close combat. Every type of military vehicle, with the exception of motorcycles, can be employed for operations in the desert when modified for use in such terrain. The rough ground surfaces, sand, and extreme heat make motorcycles useless for combat purposes. Many of the difficulties which will be encountered can be overcome by foresight and careful training. Certain modifications should be made and special equipment provided for the present authorized military vehicles when they are to be used in desert operations. The changes necessary to overcome the unusual conditions which will be encountered are discussed in the succeeding paragraphs.

■ 20. COOLING SYSTEMS.—*a.* Because of the difficulty of water supply, all water-cooled vehicles should be equipped with condensers in order to prevent wastage and reduce consumption. While some water is lost by evaporation, most is lost by being splashed up and driven through the overflow pipe by steam. The use of condensers will prevent this.

b. The drainage cock of the cooling system should be replaced with a screw cap, flush with the end of the pipe. It will seldom be necessary to drain the radiator, and there is serious danger of the drainage cock being knocked off by stones thrown up by the wheels and all the water being lost, a real calamity in the desert.

■ 21. AIR FILTERS.—*a.* There is always some sand in the air in the desert, more is stirred up by the passage of vehicles, and during a sandstorm the amount may be such as to prohibit movement. Without adequate protective measures the sand will choke carburetors, plug feed lines, score the cylinders, damage the distributor, and increase the wear on all bearings. The oil bath air filter now standard on all military motor vehicles will protect the motor *if it is kept clean*. Constant, close supervision and daily inspection of air filters are the only ways of insuring that sand will not get into the motor.

b. The crankcase breather opening should be equipped with an effective air cleaner. Air cleaners should also be provided for any other device using an air intake, such as a vacuum booster or engine-driven compressor. Air cleaners should be located where the air stream will have the least dirt pollution.

■ 22. TIRES.—*a.* Operations in the desert will require movement over all types of terrain discussed in section I. Tires must be suitable for every type of surface which will be encountered. Most difficulty will be met in sand. Experience in the desert indicates that oversize balloon sand tires are necessary for all wheeled vehicles. The tread should be of plain rib and the tire of round cross section, as a tire with deeply corrugated tread (snow tread, for example) or with a raised flat tread will break through the crust and dig in the soft sand beneath, thus stopping the vehicle and requiring it to be dug out (see par. 26). Air pressure must

be varied to suit the type of ground surface. Over sand or soft powdered clay, the ground pressure per square inch should be reduced to the minimum. By deflating the tires the area in contact with the ground is increased and the tire fits itself to the irregularities of the sand without breaking through the crust. The minimum pressure must be determined by test for each type of vehicle. Tires on flat-base rims will spin on the rims if pressure is too low. It has been found that tire life is very little shortened by running soft over sandy ground which does not contain rocks or imbedded boulders.

b. In rocky or boulder-strewn ground, tires must be as fully inflated as the age and condition of the vehicle permit. It must be remembered that fully inflated tires will result in an increase in the shock transmitted to the vehicle and its load when moving over rough or rocky ground. At low pressure the innermost layers of canvas will be broken by the violent inward bending when a sharp rock is struck. (See par. 7.) The resulting chafing will wear out the inner tube even though no danger is apparent from the outside of the tire. Since a normal day's march will take a vehicle over different kinds of ground, strict tire discipline is necessary. A high percentage of vehicles should be equipped with motor-driven air pumps to insure rapid adjustment of tire pressures.

c. Many vehicles and weapons mounted on pneumatic tires have been lost in recent desert operations due to their inability to move rapidly on tires punctured by bullets. The so-called "run-flat" tire, made with a heavy side wall, an inner rim cushion, and a special tube, which will not collapse when punctured, should be provided for use on all wheeled combat vehicles and pneumatic-tired weapons. It must be remembered that these tires are not designed to run flat except in emergency and their life when so used is only about 80 to 100 miles. Whenever a run-flat tire is punctured, if the tactical situation does not require the vehicle to continue, the tire should be changed and repaired before it is used again.

d. As a result of many trials, both by military forces in the desert and by commercial companies operating there, it is believed that a dual tire is unsuitable for desert travel. The opposing lateral forces exerted by the two tires breaks the

crust on sand, soft sand piles up in front of the tires, excessive driving thrust is exerted, and the vehicle is stalled. When the vehicle is stalled in this manner it must be dug out.

e. The life of tires, as of all rubber, will be short at best due to the heat, sand, and rough ground surfaces. Provision must be made for tire replacements greatly in excess of expectations for normal terrain. It must also be remembered that tires will deteriorate very rapidly in storage in the desert and special covered, ventilated, storage facilities should be provided when possible. Latex-filled puncture-proof tubes in storage must be frequently turned to prevent the accumulation of the latex at one point and the consequent unbalancing and weakening of the tube.

■ 23. SPARE PARTS.—The heat, sand, and rough ground surfaces all combine to shorten the life of motor vehicles and increase the need of spare parts. Parts of all kinds must be readily available in quantities greater than are planned for operations in normal terrain. Standardization of vehicles is particularly important due to difficulties of transportation and storage facilities, as well as the high replacement percentage. Cracked blocks due to overheating will occur much more frequently than is to be expected under more normal conditions. The following parts have been found particularly necessary by past experience:

- a. Rear axles and axle bearings.
- b. Spring shackles, shackle bolts, complete sets of front and rear springs, and spare leaves.
- c. Water pump and gasket, fan belt, water hose, and clamps.
- d. Distributor parts, condensers, brushes, spark plugs, wire, clamps, and tape.
- e. Wheel and tire lug nuts, plugs for oil drainage fittings, spare caps for gas tank, radiator, and storage batteries.
- f. Extra speedometer and cables for all vehicles which may be called upon to function alone, that is, scout cars and other reconnaissance vehicles.

NOTE.—Odometer readings are a vital part of desert navigation.

g. Windshields (frequently so damaged by sandstorms as to be useless).

h. Carburetors and fuel pumps.

■ 24. MAINTENANCE.—Maintenance as prescribed in present manuals will keep vehicles in condition to operate in the desert. (See FM 25-10.) The importance of maintenance must be impressed on all concerned, with special emphasis placed on first and second echelon maintenance. Supervision will be difficult under combat conditions, as vehicles cannot be brought close together for inspections or other checks. (See par. 28.) Break-downs on a march, particularly of patrols or other small units, may result in the loss of all the occupants as well as the vehicle itself. The importance of driver maintenance must be impressed on every member of a unit. The excessive jolting makes it necessary to tighten frequently all body bolts and nuts. Drivers must be trained to make this a regular part of their daily routine.

■ 25. SPECIAL EQUIPMENT.—*a.* Every wheeled vehicle must be provided with the equipment necessary to extricate it from soft sand. Driving wheels must be given a firm surface. For vehicles with single tires on driving wheels an excellent solution is the provision of a pair of steel channels 4 or 5 feet long, carried on the sides of the vehicle body. In cross section the channel should have a curved bottom wide enough to take the whole width of the tire at low pressure. It should be bent up sharply at the sides to prevent the tires running off, and then down again to form a rounded flange on each side to strengthen the channel. Two angle irons projecting from the underside and holes punched in the bottom will prevent the channel from slipping under driving thrust. Mats should be provided to form a roadway for front wheels. Canvas strips, stiffened by lateral rungs of steel sewn between two thicknesses of canvas, have been found excellent for this purpose. Such mats can be rolled up for transport and rolled out in front of each front wheel when needed.

b. Lightweight and mediumweight dual-tired vehicles may be provided with a single round wooden spar instead of channels. The spar should be placed between the tires and used as a rail. Heavy dual-tired vehicles should be provided with a pair of double channels similar to those provided for single-tired vehicles. Dual-tired vehicles will be stuck in sand much more frequently than single-tired vehicles. (See par. 22.)

c. All vehicles should be equipped with at least two short-handled shovels for digging out of soft sand. Tow hooks and tow cables should be provided for every vehicle. Power-driven winches to extricate stalled vehicles will be of great value in traversing bad stretches of desert.

■ 26. DRIVER TRAINING.—Practice in driving through stretches of soft sand and among sand dunes is necessary for all vehicle operators. Desert driving calls for the highest skill on the part of the driver, since the necessity for dispersion and for avoiding the tracks of a preceding vehicle require a high degree of individual effort. It will take a great deal of experience to develop the quick eye necessary to select the best ground and the proper gear, the skill required to make maximum use of momentum and to shift gears rapidly, and the care to avoid sudden driving or braking thrust. Even with the most skilled driving, vehicles will frequently be stuck in the sand. The following points must be firmly impressed on every driver by repetition in training:

a. The driver must be taught to give up all efforts to get out of the sand by means of his motor the instant the vehicle has broken through the crust and ceased to move. Otherwise, the driving wheels will merely sink deeper into the sand and extrication will be made more difficult.

b. The driver, vehicle commander, or one of the crew must reconnoiter the ground both ahead and to the flanks for the nearest patch of firm surface. While this is being done the channels, mats, and shovels should be unloaded. Based on careful reconnaissance, a decision must be made whether to go ahead or to back out.

c. Adequate excavations must be made in front (or, if backing out, in rear) of the wheels so that the near ends of the channels or mats are on a level with the bottom of the tire tread, and so that the slope of the channels is not too steep. If this is not done the motor will be unable to set the vehicle in motion up the initial slope to enable the wheels to begin to drive against the firm surface of the extricating equipment. Once in motion, the vehicle should be driven to firm ground or stopped headed down a slope to avoid getting stuck again after the channels have been loaded on.

d. To avoid breaking through the crust when starting, vehicles should always halt, when possible, on hard ground or headed down a slope.

SECTION IV

MOVEMENT

■ 27. GENERAL.—It will usually be impossible to conceal large movements of troops or supplies in the desert, except night movements during the dark of the moon. While heavy sandstorms will conceal troops from observation, these storms also make movement over any but the shortest distances very difficult (see par. 12). Because of the difficult driving conditions and navigation difficulties, movements have been habitually made during the hours of daylight, except when in close proximity with enemy ground forces. Since there are almost no roads and but few good desert tracks exist, movement will usually be across country. Desert conditions preclude the movement of troops on foot except during actual combat. The necessity for dispersion makes movement by units larger than a battalion very difficult to control. Battalions should normally stay within visual distance of adjacent units.

■ 28. MOVEMENT DURING DAYLIGHT.—*a.* Combat vehicles and personnel carriers must move in a dispersed formation because of the constant danger of air attack. The formation must be irregular, the vehicle echeloned and dispersed both in width and in depth. Intervals and distances must never be less than 100 yards and must be increased to 200 or 300 yards when enemy air forces are active. The same distances and intervals that are maintained during the march must be kept during daylight halts. Lines of vehicles must be avoided, both when moving and at a halt. Movements of combat vehicles should be protected from hostile ground forces by a covering screen of fast-moving armored vehicles to the front, flanks, and rear. These security troops must include antitank and antiaircraft weapons capable of immediate action. (See sec. VI.)

b. Trains must move in a dispersed formation similar to that adopted by combat vehicles and personnel carriers. Protection should be provided by attaching combat vehicles, Infantry in personnel carriers, and antitank and antiaircraft weapons. The strength of such protective forces will be governed by the situation. The vehicles of this protective

force should move at the front, flanks, and rear of the formation. Antitank and antiaircraft weapons should normally move on the flanks, disposed in depth.

c. An average speed of from 15 to 20 miles an hour, depending on the terrain, can usually be maintained for short movements in a dispersed formation during daylight hours. Supply convoys do not usually exceed a rate of march of about 10 miles per hour for trips of more than 25 miles.

■ 29. NIGHT MOVEMENTS.—Movements at night should be made without any vehicular tactical or night driving lights. Smoking and the use of flashlights must be forbidden. If the moon is bright, march formations similar to those used during daylight should be used. When night movements are made during the dark of the moon, units should be formed in small columns of 15 or 20 vehicles, with columns traveling abreast. Distances usually should not exceed 5 yards between vehicles and intervals should be about 10 yards between columns. Maximum speed must be reduced to 10 miles per hour or less, depending on the visibility and terrain. Antitank and antiaircraft weapons should be in the flank columns. In train movements the escorting vehicles should move at the head of each column and on the flanks of the march formation. (See sec. VI.)

■ 30. MOVEMENTS ON ROADS.—Such movements will be unusual in desert operations. Where roads do exist and when there is no threat of hostile ground attack, movements may be made in column. A vehicular density of 10 to 15 vehicles to the mile should be maintained. Greater density will offer excellent targets for air attack; lesser density will result in loss of control. Antiaircraft protection must be provided and should take position on the flanks of the column in the event of air attack. Antitank weapons should cover possible approaches of hostile armored vehicles.

■ 31. NAVIGATION.—The almost complete absence of roads, trails, and landmarks in the desert makes it necessary to use special equipment and methods for maintaining direction and for locating positions. Maps are of value primarily as charts from which the magnetic bearings for movements are determined. As installations are established in a given area the locations are plotted by coordinates on the map.

The bearing of a desired movement is then determined from the map by protractor. The methods used for navigating will depend upon the type of the terrain to be traversed, the knowledge of the area in which the movement is to be made, and the length of the march to be taken. Various proven methods are indicated in the following paragraphs.

■ 32. MAGNETIC COMPASS.—In making short moves when visibility is good, a course may be laid by magnetic compass and odometer. Such a course must be checked frequently, will be quite inaccurate, and will result in a slow rate of march since the compass operator must stop his vehicle, dismount, and move away from the vehicle so that it will not influence his compass. The bearing of the desired course is determined from the map by protractor. Using a compass, the leader's vehicle is turned until its long axis is pointed in the proper direction and the odometer reading is noted. The driver picks out some object or location to his front and drives to it where the move is plotted on the map and the procedure repeated.

■ 33. PREDETERMINED COURSE WITH SUN COMPASS.—This is the simplest method of navigation over any considerable distance. A map and protractor, sun compass, accurate odometer, two accurate watches, and an almanac are required. The desired direction is determined by the map and protractor (or the prismatic compass). The sun compass is corrected for the date, sun time, and latitude of the starting point, the vehicle turned until the shadow of the pointer falls along the shadow needle and the vehicle is on the correct bearing. The odometer reading is noted. The shadow needle must be corrected every 15 minutes to maintain the course. The principal objection to this method is the reluctance to alter a course once set, with the consequent tendency to drive straight through areas of bad going instead of making detours around them. In sand dune or in rocky areas it is impossible to hold to a straight course for any considerable distance.

■ 34. DEAD-RECKONING NAVIGATION.—This is the most useful method for all movements and is the only satisfactory method so far developed for movement over long distances or in unknown terrain. It requires a good sun compass which indi-

cates directly and continuously the bearing on which the vehicle is travelling, no matter what that bearing may be, and which will permit readings to be taken by the eye alone, without requiring any part to be set by hand whenever a reading is desired. The general direction of movement is plotted with map and protractor. The commander is free to pick his route over the best terrain as he goes along. The navigator notes the compass reading for each change in direction and the odometer readings and plots the actual course followed on the map or a chart. Errors in a course plotted by dead-reckoning, by an experienced navigator using the above method, should not be over 3 percent in distance and $1\frac{1}{2}^{\circ}$ in bearing.

■ 35. POSITION-FINDING.—Since navigation errors are liable to accumulate from day to day, it will be necessary, on long marches, to take astronomical fixes of the position each night. This requires a sextant or theodolite, radio time receiver, two reliable watches, an almanac, navigation (mathematical) tables, and plotting equipment.

■ 36. NIGHT NAVIGATION.—Magnetic compasses are ordinarily used for night navigation. Some sun compasses can be adapted to night navigation when the moon is bright. In general, less accuracy is expected in night navigation than in daylight. One method widely used with a magnetic compass has been to take the magnetic bearing of a low star and drive on it, rechecking every 15 minutes if the star is generally in the north or south and every 30 minutes for one in the east or west.

■ 37. OTHER NAVIGATING INSTRUMENTS.—Magnetic aerocompasses have been tried for desert navigation by dead-reckoning. The difficulty of compensating such compasses against the errors introduced by the vehicle, its moving steel parts, and the movement of metallic loads and of weapons has, up to the present, made them too uncertain for long movements over unknown country. Magnetic compasses are not usually dead-beat (nonoscillating) as is a sun compass, and the constant shifting of the needle makes accurate reading of a course bearing extremely difficult when the vehicle is in motion. A gyroscopic compass is dead-beat but must be

corrected every 10 minutes or so for precision. This correction must be made from the magnetic compass and will usually require the vehicle to be stopped because of needle fluctuation. In addition, it does not eliminate the difficulty of accurate magnetic compass adjustment discussed above. Further development may eliminate the difficulties heretofore encountered. Provision of a suitable compass of the type used in air navigation will increase the rate of march which is now held down by navigation difficulties.

■ 38. NAVIGATORS.—Every officer and noncommissioned officer of a force intended for desert operation must be able to navigate with magnetic and sun compasses and odometer. Every unit which may be called upon to operate independently must have one and preferably two navigators who are trained and equipped to determine position by astronomical means. (See par. 35.) Each member of a patrol should have an oil prismatic compass and map on his person. He should know how to use his compass, note bearings and distances, plot with protractor and scale, and should know the odometer correction of his vehicle. (See par. 32.) It must be remembered that unit trains will frequently be required to navigate to and from supply installations, and sufficient trained personnel will be required to direct their movements.

SECTION V

CAMPS AND BIVOUACS

■ 39. GENERAL.—In camps and bivouacs, as in movement, dispersion is the primary means of protection against air attacks. During daylight hours there is a constant threat of air attack and, in forward areas, of ground attack from any direction. At night the threat of air attack is considerably reduced but the danger of ground attack, particularly raids, is increased. Maximum use must always be made of camouflage. (See sec. IX.)

■ 40. DAYLIGHT BIVOUAC.—During the hours of daylight units should form a dispersed bivouac. Vehicles should be disposed in generally the same manner as when moving during the day. Intervals and distances may be still further increased for protection against air attack. (See par. 28.)

Care must be taken to avoid lines of vehicles. An all-around defense should be maintained and patrols, with suitable means for communication, sent well out to give early warning of hostile ground threats. Artillery, antitank, and anti-aircraft weapons must be placed in position and manned at all times. Slit trenches should be dug for all personnel.

■ 41. NIGHT BIVOUAC.—The following methods have been developed by troops now engaged in desert warfare. When a halt is made for the night, units the size of a battalion form a close bivouac. Vehicles form a triangle or square, with all vehicles facing in the direction in which they are to move in the event of a night alarm. The subordinate units occupy a leg or side of the bivouac formation with 10 to 15 yards between vehicles. Trains should be brought forward after dark and moved inside the triangle or square. If trains have to form a close bivouac without protection from their own unit, the train defense vehicles (see par. 28) form an outer circle within which the supply vehicles take up an irregular formation.) Night listening posts are established at sufficient distance from the bivouac to give warning of ground attack. Communication should normally be by wire or messenger because of the necessity for radio silence. Frequently it will be advisable to patrol between listening posts. Before dawn the trains should move out of bivouac and take up open formation to the rear. At dawn the unit establishes an open (dispersed) bivouac, adopts the dispersed formation for movement, or the prescribed formation for combat. When there is no danger of an attack by hostile ground forces the open bivouac formation is used both day and night for air protection. Separate organizations smaller than a battalion adopt formations similar to those of the battalion. Units larger than a battalion should not form a close bivouac.

■ 42. SECURITY MEASURES IN BIVOUAC.—Whenever a unit goes into bivouac, plans and preparations must immediately be made to move out if the necessity arises. The ground in the vicinity of each unit is reconnoitered so that units can move out without confusion. Vehicles are headed in the direction of movement, are serviced, and supplies are issued. Slit trenches are dug for cover, air lookouts posted, and all anti-aircraft weapons constantly manned. Antitank weapons

and machine guns should be so sited along the perimeter of a close bivouac as to cover adequately all possible approaches. Lights necessary for administration, maintenance, or cooking after dark must be carefully concealed from air or ground observation. Radio silence should be observed for at least a half hour before going into bivouac and during the hours of darkness except in an emergency. Close bivouacs are usually formed about dusk. If there is any danger of being observed from the air or ground, close bivouac should not be established until after dark. If a bivouac has been established during daylight hours it should be moved after dark. Troops in contact with the enemy, in static position, normally form close bivouac by company or battery during the night, securing the bivouac with listening posts and patrols.

■ 43. CAMPS.—It will be impossible to conceal the existence of camps of a permanent or semipermanent nature. Protection of such installations will normally be gained by dispersion over such a large area that air attack directed at the whole installation will be unprofitable and by the use of dummy installations. Camouflage and camouflage discipline must be used to insure the concealment of the more important locations, such as command posts, telephone centrals, etc., from possible point attack. Roads should be clearly marked and military police must control traffic. No vehicle should be permitted to approach closer than 300 or 400 yards to a command post or similar installation. Vehicle parking areas should be concealed and dispersed.

■ 44. SHELTER.—In bivouac, individuals find shelter in vehicles, in tents, in slit trenches, or in dugouts. Except in the winter along a coast line, rain usually will not be encountered in the desert, hence sleeping bags may be used on the open ground. Shelter will be needed from the wind, particularly in the winter. Tents should be dug in and camouflaged. Where positions may be occupied for relatively long periods of time, dugouts should be constructed for shelter. Command vehicles must be provided with lightproof shelters, preferably capable of extension to the sides to provide sufficient working space. Slit trenches must always be dug to provide cover in the vicinity of the shelter.

SECTION VI

RECONNAISSANCE AND SECURITY

■ 45. GENERAL.—The almost complete freedom of maneuver in the desert, generally limited only by supply considerations, demands all-around security measures and aggressive and continuous reconnaissance. Air reconnaissance during daylight hours, unless conditions of haze or sandstorms exist, should discover the movements and locations of large forces in sufficient time to prevent surprise. It will, however, be difficult to discover from the air small patrols and raiding parties which use hit-and-run tactics. These must be sought out by ground patrols. In order that full advantage may be taken of freedom of maneuver the ground must be carefully reconnoitered to insure that movement is made through the most suitable areas. Failure to execute tactical ground reconnaissance has frequently resulted in armored forces being decoyed into antitank ambushes with disastrous results. While danger from hostile mine fields will frequently prohibit night movements in areas which have been in the hands of the enemy, the same mine fields will not prevent the enemy from moving at night. Therefore it is vital that night bivouacs be secured against hostile action.

■ 46. SECURITY.—*a. During daylight.*—Security is provided by adopting a dispersed formation during movement and at halts, and by the use of patrols to the front, flanks, and rear. (See par. 28.) Surprise attack by ground forces is practically impossible if adequate reconnaissance measures are taken. The threat of hostile air attack is always present and antiaircraft lookouts must be posted, antiaircraft weapons manned at all times, and an adequate warning system established.

b. At night.—Movement of large forces will be difficult at night. It should not be attempted unless a protective screen has been established during daylight around the area through which the movement is to be made, routes have been reconnoitered and marked, and guides provided. Night bivouac areas should be occupied after dark to prevent air attack and the formation adopted should be a close bivouac unless there is no danger of raid by ground forces.

(See par. 41.) Security of a night bivouac is obtained by the close formation, the siting of defensive weapons on the perimeter, the use of all-around listening posts, and night patrols. Sound carries very well at night and listening posts will normally provide adequate warning of hostile raids. The operations of security patrols at night will require careful coordination with the listening posts in order that the patrols will not confuse listening posts with resulting false alarms. Patrolling should be intensified before daylight to assure safe movement to the dispersed daylight formation. (See par. 28.) Slit trenches should be dug for cover against ground attack. Security from air attack is provided by light discipline, radio silence, and plans for dispersal in the event of air attack.

■ 47. GROUND RECONNAISSANCE.—Highly mobile patrols equipped with radio and armed with suitable weapons for protection against armored and air attack should be used for ground reconnaissance. Each patrol must be prepared for all types of desert navigation (see sec. IV). Patrols should *never* have less than *two* vehicles in order to provide against vehicle break-down. Normally personnel used for this duty should be specially trained.

■ 48. DAY PATROLS.—*a.* These patrols must be mounted in vehicles capable of high speed in order to extricate themselves from any sudden attack by superior forces. Fast armored vehicles are particularly well suited for day patrols. Antiaircraft and antitank weapons and radio communication are essential. Among missions for day patrols will be the following:

(1) To maintain contact with the enemy and to report his movements, composition, and disposition.

(2) To observe and report the enemy's tactics, methods, formations, employment, and types of transport.

(3) To locate hostile defense positions, gun and machine-gun posts, wire, mine fields, and other obstacles.

(4) To collect identifications such as measurements of track and wheel marks, letters and documents, and pieces of uniform and equipment.

(5) To obtain thorough information of the terrain for its future tactical use.

b. Day patrols are very vulnerable to air attack. Constant lookout must be maintained for hostile air attack. A widely dispersed formation must be used. Halts should be made on ground most suited for concealing vehicles and maximum use made of camouflage. When attacked from the air, the personnel should scatter away from the vehicle and fire at the attacking airplanes. Aircraft always attack the vehicle. In static situations, patrols must avoid habitually following the same route in order to protect themselves against ambush or mine fields laid overnight.

■ 49. NIGHT PATROLS.—a. Night patrols are essential in the desert both for security and reconnaissance. Such missions are best performed by motorized Infantry. Armored vehicles are generally unsuitable for night missions. The operations of a night patrol will usually entail an approach march by motor to a detrucking point and an advance on foot toward the objective, the close reconnaissance or penetration and assault of the objective, and finally the withdrawal of the patrol to the entrucking point and a return march. The strength of a night patrol must be sufficient to provide protection for the vehicles at the detrucking point in addition to the troops necessary to accomplish the dismounted mission.

b. Night patrols in the desert demand excellent physical condition and a high degree of training on the part of the troops used. Patrols may be required to cover considerable distances on foot during the night, lie still for long periods close to enemy positions, and operate under extremes of heat and cold. The accomplishment of such a mission demands—

(1) Careful organization of the patrol and study of all information of the terrain to be covered.

(2) Accurate navigation both while in vehicles and on foot.

(3) Ability to negotiate difficult terrain rapidly and silently and to maintain formation.

■ 50. DISTANT GROUND RECONNAISSANCE.—Because of the great areas involved and the almost total absence of major natural obstacles to movement, desert operations permit the effective use of ground patrols operating over distances of hundreds of miles from their bases. Patrols used for this

purpose must be specially organized, equipped, and trained (see app. II). Their missions will include the obtaining of detailed topographical information, discovery of hostile movements or other activities in distant areas, and raids for the destruction of supply dumps, harassing supply columns, and diverting hostile forces to protect isolated posts and lines of communications.

SECTION VII

COMBAT

■ 51. CHARACTERISTICS.—Because of the conditions found in deserts, combat in such terrain is marked by the following characteristics:

a. Forces have almost complete freedom from those restrictions on mobility normally imposed by natural tactical obstacles. Hence, maneuver and all-around protection are emphasized, and the maximum use of motor transportation is possible.

b. The scarcity of roads and railways increases supply difficulties and limits the radius of action of mechanized and motorized forces.

c. The almost total absence of natural concealment, other than that provided by haze or mirage increases the importance of dispersion and deception.

d. The absence of good landmarks reduces the value of maps, necessitates accurate navigation by use of compass, sun, and stars, and increases the difficulties of controlling maneuver and of cooperation between various arms and different units.

■ 52. MANEUVER.—Ultimate success in battle in the desert will generally be dependent upon the success of the armored elements. Quick and flexible maneuver of armored and motorized units is essential to exploit fully enemy weaknesses and mistakes, and bring full fire power to bear on the enemy under the most favorable conditions. Quick and flexible maneuver requires use of the most suitable formation, maintenance of direction, and correct use of speed and ground.

■ 53. FORMATIONS.—Formations must be adapted to secure rapid movement and protection against surprise. There is

a constant struggle between dispersion and control. The ever present threat of air attack makes a dispersed formation essential, yet the greater the dispersion the greater the difficulty of control. The basic unit for the movement of Armored Forces or motorized Infantry is the battalion. In order to control this unit the development of battle drill is essential. In a dispersed formation, change of direction and changes of position of subordinate units are very difficult. To assist in such actions commanders of all units should march well forward, and all vehicle commanders and drivers must be thoroughly familiar with the signals and the types of maneuver which may be used.

■ 54. MAINTENANCE OF DIRECTION.—Navigation is always difficult. Constant training of navigators for all units is necessary. Bearings for the direction of movement are given before the movement starts. Changes of direction are very difficult to make in a dispersed formation. Practice in battle drill is the only method by which the necessary flexibility will be developed.

■ 55. SPEED.—Proper use of speed is essential for success. Driving beyond the economical speed of the vehicles must be avoided. Fast driving of vehicles will result in frequent mechanical failures and in high wear and tear on vehicles. High rate of movement is obtained by intelligent anticipation by commanders, by good judgment in the use of ground, and by good driving. Commanders of all echelons must anticipate the possible employment of their commands and make early readjustment in the disposition of their subordinate units in order that they may be quickly employed where needed. While the ground in the desert is relatively open and flat, there will always be areas of good going and bad going. The commander's intelligent use of ground for maneuver may frequently force the enemy into using rocky or other poor ground, while comparatively good ground conditions are used by the commander's own troops. Such use of ground requires taking every opportunity for personal reconnaissance, and the development of a keen and quick eye for desert terrain in order to select ground which is especially suitable for fire action and for the employment of reserves. The importance of good driving cannot be overemphasized.

The individual driver's ability to keep his place in the formation and to get his vehicle to the proper place at the proper time without exceeding the economical speed of his vehicle will often be vital to success in combat.

■ 56. SECURITY (see sec. VI).—Since the enemy has equal freedom of maneuver, all-around protection is necessary at all times. Lack of concealment permits the use of smaller units for advance, flank, and rear guards than are required in less open terrain. Formations and the disposition of units must permit entry into action in any direction.

■ 57. RADIUS OF ACTION.—The supply difficulties which attend desert operation, due to lack of roads and railways, and the use of motor vehicles limit operations to the available fuel supplies. The problems of supply are discussed in section X. While lack of obstacles permits free maneuver; the radius of such maneuver is definitely limited by the fuel supply. Since fuel consumption varies with the type of ground traversed and with the continuity of movement, frequent periodic checks on the amount of fuel on hand are necessary during operations.

■ 58. LACK OF CONCEALMENT.—The surprise which concealment permits in other terrain cannot be counted on in desert combat. Even with air superiority it will rarely be possible to eliminate all hostile air observation. Reserves should be so located that they will be readily available when needed and maximum use made of their mobility to deceive the enemy as to their composition as well as place of employment.

■ 59. LIAISON.—The absence of good landmarks presents difficulties in cooperation between different units and arms. Training must develop the maximum use of visual signals, pyrotechnics, and other visual means of identification of unit and target locations. Liaison between all units and services must be highly developed.

SECTION VIII

ARMS AND SERVICES

■ 60. GENERAL.—*a.* Combat experience in rolling or flat desert areas indicates that all arms and services must be provided

with motor transportation. Although foot troops are employed in defensive positions or fortified localities, in close contact with and in the assault on hostile defensive positions, and in mopping up and exploiting areas which have been overrun by armored units, the foot troops must be brought to the areas of these operations by motor. Otherwise, hampered by the difficult footing, the heat, and the lack of water, they may arrive too late or so fatigued as to be unfit for combat. The lack of concealment and cover makes slow-moving foot troops lucrative targets for hostile air and armored forces.

b. Operations in mountainous desert areas require special transportation facilities. From such knowledge of these areas as is now available, few if any roads and only a limited number of trails exist. Because of the difficult terrain conditions and the lack of water, operations probably will be limited to native troops and specially selected task forces. The composition and strength of such forces will be influenced primarily by water supply.

■ 61. INFANTRY.—In the attack, Infantry will generally have the subordinate role of supporting the operations of armored units. Infantry attacks have little hope of success in bare, open desert terrain unless there are present at least some of the following favorable conditions: supporting tanks, overwhelming supporting fires, close support combat aviation, and darkness, smoke, or dust storms. The open desert places a premium on the speed, the shock, and the fire power of the armored vehicle. Infantry moves by motor; it supports the armored action by executing reconnaissance, by protecting assembly, refueling, and bivouac areas and the passage of defiles (that is, escarpments, extremely rough ground, soft sand, and salt marshes which frequently restrict the movement of mobile forces). Infantry may be used to establish bridgeheads through mine fields, tank traps, and other obstacles to armored unit operations, and to follow closely the armored attack to hold the ground gained, to mop up remaining hostile forces, and to exploit the success achieved. It may be used to protect or escort the supplies of armored units. In combination with other forces it may be employed in pursuit to block routes of retreat at defiles or other crit-

ical terrain while armored elements complete the destruction of the trapped enemy. The Infantry must be amply provided with antiaircraft and antitank guns and be reinforced with artillery and engineer troops.

■ 62. DAYLIGHT RECONNAISSANCE.—Since enemy air and artillery action will be most effective and hostile armored vehicles will probably be operating during daylight, mobile ground reconnaissance for the main forces will normally be executed by armored patrols. In many situations, observation posts manned by Infantry must be operated during daylight hours. Such posts may be established to advantage prior to daylight and withdrawn either during the midday mirage or after dark. When these posts are established the personnel must dig cover and conceal their vehicles. A considerable distance will often have to be traversed on foot to take full advantage of the ground and to prevent the sound of the vehicles from disclosing the location of the post. Some personnel must always remain with the vehicles to protect them or to permit rapid get-away should that become necessary. These posts must have adequate signal communication facilities to their supports or main bodies. It may frequently be possible to set up forward radio stations connected by remote control or by telephone or runner to one or more observation posts. When runners are used, covered routes should be available for their movement. Specially equipped and trained motorized Infantry may be used for long-range ground reconnaissance. (See app. II.)

■ 63. NIGHT RECONNAISSANCE.—Reconnaissance at night will be a most important infantry task. Such a mission will frequently require movement by motor and on foot. The strength of reconnaissance units for these missions must be such as to assure protection of the vehicles during the operations of the dismounted personnel. (See par. 49.)

■ 64. DEFENSE AND DELAYING ACTION.—Motorized infantry units, heavily reinforced with artillery and antitank guns, will be particularly well adapted to defense and delaying action because of their great automatic fire power and the speed with which reserves can be moved to reinforce any threatened point. Depth in defense is not so important unless a protracted defense is indicated. A defensive line taken up

with the primary purpose of checking hostile armored and motorized columns should always, if possible, be based on a natural or artificial tank obstacle. This will permit a much longer line to be held. A short line is of little value against highly mobile forces as it will be speedily and inevitably out-flanked. When a long line is occupied, it will usually be found possible to concentrate the bulk of the antitank weapons on the most likely approaches and to observe and patrol areas which are less suitable for armored vehicles. Although such a line, particularly with artillery support, can impose considerable delay during daylight, it will be of small value at night against an enemy who may be able to bring up Infantry to reconnoiter and attack the position. At night close bivouac should be formed and positions organized which command the most likely enemy approaches.

■ 65. PROTECTION.—*a. General.*—Infantry will be required to protect itself and other forces at the halt, on the march, by day and by night. By day the force protected and its escort should move or halt in a formation which provides well-controlled dispersion, thus giving the enemy a difficult target to engage whether from the air or ground, and giving the commander an opportunity to maneuver at speed and thereby avoid engagement with superior enemy forces. Since attacks may come from the air or from any direction on the ground the protective measures taken should provide—

(1) Air sentries and ground patrols, both with adequate signal communication so as to give early warning of an impending attack.

(2) A mobile reserve at the immediate call of the commander to engage enemy attacks.

b. Air attack.—For protection against air attack the following measures are necessary:

(1) An air sentry in *every* vehicle on the move, and as required at the halt.

(2) Dispersion of vehicles in width and in depth. When moving across country or when halted in daylight, intervals and distances of from 100 to 300 yards between vehicles must be maintained. Personnel must remain dispersed at a halt.

(3) All anti-aircraft weapons must be constantly manned and ready to open fire. Location of anti-aircraft weapons

at the front, flanks, and rear of the formation will be most effective, providing the entire area occupied can be covered by some or all of the weapons.

(4) Strict discipline must be maintained as to lights and direction and rate of movement. Dust raised by rapid movement may disclose vehicles which otherwise would be unnoticed. On roads, movement should be as rapid as is consistent with driving safety in order to reduce the time spent in the danger area. Antiaircraft weapons should, when possible, protect such movements from positions on the flank and *not* in the column.

c. Night.—For administration and protection some degree of concentration is usually necessary at night. No matter what the formation, plans must be made for complete all-around defense, adequate ground patrols and listening posts, and for the rapid resumption of movement. All troops must have definite alarm positions suitable for both air and ground attack. Indiscriminate firing at night must be avoided as it discloses the position to enemy aircraft and to ground patrols. All troops must be impressed with the relative ineffectiveness of fire at night, owing to the fact that aim cannot be taken in the dark. Night firing is often more dangerous to friend than to foe. Hostile combat patrols, once they have gained access to a close bivouac, will attempt to create confusion and cause uncontrolled firing to cover the accomplishment of their missions.

■ 66. ARMORED FORCES.—*a. General.*—The lack of natural obstacles to movement makes desert terrain most suitable for the use of armored forces. The final decision in a desert campaign will depend upon the success of the armored elements. The composition and action of other arms and services is of importance to the degree in which they are able to contribute to the success of the armored elements of the command. (See par. 69c.)

b. Battle maneuver.—Lack of concealment will make it relatively impossible to hide the presence of armored units. All forces operating in the Libyan Desert have made great use of camouflage to make armored vehicles appear to be other types of vehicles. They have also made considerable use of dummy tanks. Surprise in armored operations can be gained sometimes by night movements but primarily by

the use of the speed and mobility of the tank. In order to make full use of these factors, battle maneuver must be developed. The necessity for dispersion makes control difficult. Constant drill and maximum efficiency will be required in the use of radio and visual signals in order to develop in all personnel the familiarity with signals and types of maneuver necessary.

c. Replenishment.—Tank action in present desert operations has made refueling and replenishing of ammunition during intervals between tank actions vital to success. The speed necessary to accomplish these tasks effectively will only result from perfect teamwork on the part of both tank crews and the personnel of supply vehicles, developed by careful training. Dispersion must be maintained during this operation. Expert navigation is a necessity to assure all vehicles arriving at refueling areas.

d. Recognition.—Failure to identify tanks has resulted both in the loss of many tanks by the action of friendly air, ground, and other tank forces, and in losses inflicted on friendly ground troops by their own tanks. Flag recognition signals have proved inadequate because of the great clouds of dust and sand which usually envelop a tank during movement. A simple visual signal code, to be given when called for, using Very lights or colored smoke, is a necessity. Such a code must be capable of frequent variation.

e. Recovery.—An efficient recovery system must be developed. German armored forces operating in the Libyan Desert have their recovery crews accompany the tank elements at all times and recovery is normally started during a tank battle. Consequently, they have been unusually successful in returning a large percentage of vehicle casualties to operating condition within a relatively short period of time.

f. Artillery support.—Armored artillery, preferably self-propelled, should accompany the armored forces. The great importance of artillery support in tank action has been proved in all operations in the desert. Prior to the tank-versus-tank action its missions will include denial of certain areas to hostile tanks, antitank fires, fires which deceive the enemy as to the direction of attack, blinding observation by smoke, and counter battery fires. During a tank-versus-

tank action the principal artillery mission will be counter battery fire and interference with movement of hostile reserves and with hostile replenishment efforts. Armored artillery must have protection by motorized Infantry.

g. Organization.—The operations which have taken place in the Libyan Desert during the present war have involved a comparatively small number of troops which have had relatively great areas over which to operate. Under these conditions the commanders of the highly mobile units, particularly the armored units, have usually had the choice, limited only by the availability of fuel, of accepting or refusing combat. As a result of these special conditions, both forces have tended to increase the proportion of supporting troops and reduce the number of tanks in a task force. (See app. III.)

■ 67. CAVALRY.—The lack of water prohibits the use of horse cavalry in the desert. Mechanized cavalry will be valuable for the performance of reconnaissance and security missions and in delaying actions. The reconnaissance and security missions for motorized Infantry can be executed by mechanized cavalry. (See par. 61.)

■ 68. ENGINEERS.—*a. Principal tasks.*—The principal engineer tasks in desert operations will be the reconnaissance and removal or destruction of antitank obstacles, development of water supply, destruction of disabled hostile armored vehicles and, in withdrawal, of water supplies, the establishment of transport and of port facilities, the construction of fortifications, and road development.

b. Antitank obstacles.—The construction of antitank obstacles, particularly mine fields, is relatively easy in desert terrain. The sand permits easy digging and the wind causes the sand to obliterate quickly all marks. Thorough and constant reconnaissance by engineers will be necessary during the preparations for an attack on any position which the enemy has had time to protect. Large mine fields can be readily installed or shifted overnight. Engineer troops will be necessary with any force attempting to establish a bridgehead through antitank obstacles prior to an armored attack.

c. Water supply.—(1) The most difficult and the most important problem in desert operations is water supply. He

who possesses water supplies in the desert and is able to destroy his opponent's is assured of victory. Engineer troops must be equipped to exploit to the fullest degree all possible sources of water. Along the coast, distillation of salt water will frequently be possible. Drills and pumps must be provided for development of subsurface water and of oases. The necessity for dispersion requires the use of multiple water-distributing points.

(2) The destruction of water supplies may impose heavier delays on a hostile advance than any system of obstacles, and engineer troops must be prepared to execute such destruction. Methods of destruction of water storage used in the Libyan Desert have been by salting and by explosives. One pound of salt to 10 gallons of water has proved sufficient to render water stored in cisterns not potable. A small charge of explosive is used to stir the water and assist solution. The charge may be sufficient to crack the cistern and allow the water to drain away. In the destruction of water in tanks it has been found that, on the principle of pressure pulse effect, one primer was sufficient to destroy a 400-gallon tank half full of water. Another method is pollution with fish oil derivatives.

d. Destruction of tanks.—In recent operations in the desert, failure to destroy disabled hostile tanks has frequently resulted in their being recovered by the enemy and restored for later use. Engineer troops should accompany or follow closely an armored attack, prepared to destroy such disabled vehicles as may have to be left on the field. The following methods and points of attack have been found effective in rendering a tank useless, even as a source of spare parts:

(1) Since spares are not normally carried by the enemy, parts to receive particular attention are—

(a) *Suspension.*—Separate one or more main suspension assemblies from the hull, and so increase recovery or salvage difficulties.

(b) *Turret.*—Damage or destroy the turret race ring. A charge exploded against the base of the turret is effective.

(c) *Gun mounting and gun shield.*—Damage or distort the shield and trunnion bearings.

(d) *Gun.*—Destroy by placing a charge in the breech (or muzzle).

(e) *Engine transmission and final drive.*—Even local damage to these assemblies by two or three charges laid in any convenient places will render the assemblies unserviceable, and, added to the damage done by fire, will reduce considerably any possible salvage value.

(2) Complete destruction of the tank by a concussion charge. Using ammonal or a similar explosive, the charge being placed inside the vehicle at the weakest points, that is, joints in the armor plate, it has been found that a total weight of charge in pounds (C) according to the formula

$C = \frac{3V}{10}$, where V is the internal volume of the body in cubic feet, will destroy the tank.

(3) Use of the tank's own ammunition for destruction. The ammunition should be placed near the final drive, all fuzes (base or point) to the center, and fired by means of a small explosive charge, one slab of guncotton for example, placed as near the fuzes as possible. The whole should be liberally doused with fuel oil and/or gasoline from the fuel tanks before firing.

(4) Burning by pouring 5 or 10 gallons of gasoline inside the tank and setting it on fire, when time for more complete destruction is not available.

■ 69. ARTILLERY.—*a. General.*—Horse-drawn artillery, just as horse cavalry, is of no value in desert operations because of the difficulties of water supply. Truck-drawn artillery will have no particular difficulties moving in this terrain. It will suffer from the lack of natural concealment both for gun positions and for truck parks. Both guns and trucks must be dispersed widely for protection against air attack, and must be provided with garnished camouflage nets. Protection from ground attack is a serious consideration and must be provided in part by other troops. Self-propelled artillery is ideally suited to desert conditions because of its great mobility. The generally flat terrain and lack of dead space and the constant threat of hostile armored attack make guns rather than howitzers more suitable for most desert warfare. In mountainous desert, pack artillery will be valuable if water supplies permit the use of animals.

b. Positions.—Positions in defilade will rarely be possible. Distances between guns must be increased to much greater

than those normally used and guns must be echeloned in considerable depth. The British have found that a small loudspeaker system aids in the transmission of fire commands to the individual pieces. The construction of slit trenches for cover for all personnel in the battery must be commenced simultaneously with the occupation of the position. Field Artillery is one of the most remunerative targets for low-flying air attack. All field artillery units must be provided with antiaircraft weapons on a scale much greater than that provided for operations in more normal terrain.

c. Observation.—Terrestrial observation of artillery fires is very difficult in the desert because of mirage and the lack of elevated positions. Forward observation posts are essential. Air observation will increase the value of artillery but will be difficult to maintain unless air superiority is obtained, because of the vulnerability of the observation airplane, and because the lack of landmarks reduces the value of maps. Survey is comparatively simple but map-fires without observation will be of little value, except against well-photographed, fortified localities. Observers for artillery which is supporting armored forces should have tanks from which to observe and should be either in the first wave of tanks or be placed on the windward flank of the formation.

■ 70. AVIATION.—*a.* Equality, if not superiority, in the air is essential for success in desert as in other operations. The lack of concealment permits the maximum obtaining of information by air reconnaissance. Better conditions for high-level bombardment normally prevail in the desert than in any other terrain. Low-flying attack is handicapped by lack of concealed approaches but is aided by the ability to locate targets from considerable distance.

b. Inability to conceal landing fields is a serious handicap. However, landing fields are easily constructed in the desert, and multiplicity of fields, antiaircraft weapons, and maximum use of dispersion, camouflage, and dummy installations permit losses of aircraft on the ground to be held to a minimum. The value of close air support of ground attack in the desert indicates the necessity for use of advanced landing fields during actual operations.

■ 71. SIGNAL CORPS.—The speed and mobility which are possible in the desert preclude very great use of wire communication except in fortified areas. Maximum use will be made of radio. Where telephones can be used, the wire lines must be buried or poles must be provided if lines are to remain in operation for an appreciable period. This is particularly true in areas where the ground is hard. No means for laying wires off the ground will be found in the desert. Newly buried lines show up readily in air photographs and great care must be used to prevent them from indicating the location of important installations, command posts for example. Vehicles must not follow wire lines, as the tracks will be seen from the air to converge at command posts and other important points.

■ 72. CHEMICAL WARFARE.—*a.* Desert conditions are not well suited to the use of chemicals. Freedom in choice of avenues of approach in most desert areas precludes the use of persistent chemicals to deny the use of ground to the enemy. The heat limits to the minimum the persistence of such chemicals. Uniformity of wind direction offers an advantage in the use of nonpersistent chemicals to support an attack; but lack of surprise, lack of personnel density in defended areas, and the velocity of prevailing winds make the value of such weapons doubtful except in an attack on fortified localities.

b. Smoke from most projectiles is inclined to pillar in the desert due to the rising currents of air. To be of any value a concentration of from two to three times that normally used is required. Smoke-producing devices on armored vehicles have proved valuable in some instances for protection and escape from ambushes.

■ 73. MEDICAL CORPS (see app. IV).—The evacuation and treatment of casualties in the desert present special difficulties due to the large areas over which action is distributed. The presence of a number of wounded in a highly mobile unit will restrict the action and even endanger the safety of the unit. Medical troops, as all others, should be provided with a greater number of motor vehicles for desert than for normal operations. Airplane ambulances will be particularly valuable for the evacuation of the more serious casualties.

SECTION IX

CAMOUFLAGE AND CONCEALMENT

■ 74. GENERAL.—*a.* The lack of natural concealment in the desert places especial emphasis on camouflage. Protective painting is used for all vehicles and matériel. A film of oil or grease should be painted on all vehicles and guns so that sand and dust will cling to the film, thus giving the object the color and texture of the surrounding terrain. Windshields, except for a narrow rectangle about 2 by 8 inches, and all bright surfaces should be similarly treated.

b. Camouflage nets should be provided for all trucks and all weapons which are to be put in position. Shadows are the principal sources of information as to the location and nature of objects, and every effort must be made to conceal or distort them, and to reduce them by digging in vehicles and weapons. Maximum use should be made of natural shadows in broken ground, dry washes (wadis), and sand dune areas.

■ 75. DECEPTION.—Lack of natural concealment and almost constantly good conditions for air observation make deceptive measures of great importance in the desert. Great numbers of dummy tanks and airplanes have been built, tank parks and landing fields organized, and realism obtained by overnight changes of location, variation of tracks by a few real tanks, and organization of air and ground defense installations. Tanks have been disguised as trucks and used to decoy hostile vehicles into ambushes. Trucks or other vehicles disguised as tanks have driven off armored reconnaissance vehicles. It is impossible to conceal supply installations, but dummy installations result in dispersion of bombing effort. In forward supply depots and dumps the nature of articles should be concealed, usually by burying, in order that hostile aircraft cannot concentrate on the more vulnerable supplies, such as fuel and ammunition. (See par. 78.)

■ 76. TRACKS.—*a.* It is impossible to conceal tracks except on rocky ground. The dispersion habitually used by vehicles in movement soon results in a maze of tracks in any area in which troops are operating. To avoid converging

tracks disclosing the location of important installations such as command posts, vehicles must follow designated routes when approaching these localities. They are not permitted to approach closer than 300 or 400 yards to discharge passengers, proceeding then to a dispersal area or concealed vehicle dugouts. The location of mine fields is often disclosed by the abrupt turns which vehicles have made to avoid the field. Proper control of such tracks may be used to deceive the enemy air observers.

b. Imagination, ingenuity, and intelligence will permit deceptive measures to play an important part in the success of desert operations. A constant pattern in the use of ruses or habitual procedure in deceptive methods must be avoided.

SECTION X

SUPPLY

■ 77. GENERAL.—a. Since the start of operations in the Western Desert in the present war, four major operations have been attempted, two offensive actions by each side. In every instance the action has been indecisive because of the failure to solve the problem of supply, not only of daily replenishment, but also the replacement of vehicles and of personnel.

b. Rail and motor roads do not exist in most desert terrain in which our troops may be expected to operate. Supply will be normally by motor across country; in emergency, by air transport if available. The absence of serious terrain obstacles in the desert makes supply the only limiting factor in the operations. The complete absence of local sources of supplies of any kind emphasizes the importance of adequate supplies.

c. Time and space schedules developed by experience in other terrain are of little value in the desert. The complete absence of roads in forward areas, the difficulties of maintaining direction, the vulnerability of supply movements and installations to attack by mobile ground forces or aircraft, the danger of sandstorms, and the loading difficulties caused by the necessity for dispersion all require a new conception of time in movement of supplies. The fluidity of armored action, the commander's ability to accept or refuse action because

of his freedom of movement, permit operations to cover space much greater than that normally considered. (See app. V.)

■ 78. DEPOTS AND DUMPS.—It will be impossible to conceal the location of supply installations of any size. Protection is gained by dispersion of all supplies over a large area and concealment of the nature of supplies by covering them. The field supply depot (division dump) for one armored division for a minor operation covered an area roughly 6 miles on a side. (See app. V.) Dispersion of enemy effort is also gained by use of dummy installations. Loading and unloading, when such great dispersion is necessary, is a time-consuming task. Careful training of supply personnel is required for such operations. During daylight hours trucks must be kept 100 to 300 yards apart and lines of vehicles must not be permitted.

■ 79. CLASS I SUPPLIES.—The conduct of unit messes is impossible in the desert when troops are within operating range of hostile fighter and dive-bombardment aircraft. Each vehicle must carry rations and water for the occupants of the vehicle, and meals must be prepared by individuals or the group assigned to the vehicle. Every vehicle should carry *as a reserve only* and *never* for daily consumption 3 days' supply of water and three rations for emergency use. Unit combat trains should carry one ration and $1\frac{1}{5}$ gallons of water per man. This requirement will influence the personnel and armament capacity of all combat vehicles. (See app. II.)

■ 80. CLASS III SUPPLIES.—The fluidity of action in desert operations results in many unexpected movements and unforeseen engagements with mobile hostile forces. Daily estimates of needs in class III supplies will frequently prove inadequate, and emergency reserves must be held readily available. Unit trains should contain at least 100 miles of fuel for the unit served.

■ 81. CLASS V SUPPLIES.—Early exhaustion of ammunition supplies has been frequent in operations in the Libyan Desert. This has been particularly true in tank, artillery, and antitank ammunition. Since the amount carried in combat vehicles is limited, it is essential that unit trains carry one

refill of all types and that mobile rolling stocks be held available and shifted in accordance with the action of the combat. Stocks dumped on the ground in the combat area have been lost more often than used in the mobile action characteristic of desert warfare.

■ 82. CLASS II AND IV SUPPLIES.—Estimated requirements in these classes of supplies should be stocked in forward supply depots. The estimates of class II supplies must be based on the high rate of breakage of vehicular parts expected in desert operations. (See par. 23.)

■ 83. PROTECTION.—*a.* The protection of dumps and of trains is particularly difficult in the desert. Dumps have been generally located so far in rear of the combat area that it has been difficult for ground forces to raid them. Mine fields are used around all forward supply depots, a field 40 miles long and 100 yards deep being used in one instance. Such fields are not protected by fire at all times. They offer protection because the great delay which they impose on raiding forces allows a mobile protective force to interpose itself between the raiding party and the supply dumps before the field can be breached.

b. Failure to protect trains from armored patrols has resulted in the loss of hundreds of supply vehicles with consequent disaster to the troops for whom the supplies were intended. Every commander must realize the vulnerability of supply columns to attack by small armored patrols and must attach sufficient infantry, artillery, antitank and antiaircraft weapons, *and tanks* to assure the protection of trains both in movement and in bivouac.

c. Air attack is a constant threat to the security of trains. Some protection will be gained from attached antiaircraft weapons but the principal protective means will be dispersion. (See par. 28.) Control of a widely dispersed formation is very difficult and drivers will require careful training.

d. Vehicles in supply columns must not disclose the nature of their loads by marking or appearance. If tank trucks are used for gasoline and water they must be so disguised as to appear, from the air at least, to be no different from other trucks in the train. These two items of supply are so vital to operations that aircraft have consistently concentrated

their attacks on such vehicles when they were able to identify them, to the exclusion of other vehicles, until the gasoline and water supplies were destroyed.

■ 84. NAVIGATION.—All supply units will meet the same difficulties in maintaining direction which other troops will encounter. Every unit will require a trained navigator and all drivers must be trained in simple navigation with map, compass, and odometer (see pars. 31 to 38, incl.). Units should provide guides to bring up unit trains.

■ 85. LOADS.—In computing loads for vehicles the rations, water, fuel, and lubricants required by a supply vehicle for its round trip must be taken into consideration. For example, in a recent operation in the Libyan Desert a round trip of 450 miles was necessary from base to refilling point, 7 days being allowed for the trip which was almost entirely across country. Over 900 pounds of the pay load per vehicle had to be used for fuel, rations, and water to permit each vehicle to make the trip.

■ 86. SIGNAL COMMUNICATION.—Radio communication between all supply echelons is vital if supplies are to be at hand where needed. Supply officers should be at the forward echelon of combat units in order to be fully informed of the needs of the unit.

APPENDIX I

MOTOR TRANSPORT

1. **GENERAL.**—Some of the more frequent difficulties experienced with motor transport in the desert are given below. By foresight and careful driver and mechanic training many of these difficulties can be prevented or overcome.

2. **OVERHEATING.**—This is a general complaint. It is particularly apt to happen when driving in the heat of the day with a tail wind and in soft ground in low gear. Vehicle should be stopped, if possible, headed into the wind, and allowed to cool. Fan belt should be examined frequently and replaced if it shows wear, otherwise it may break and, if not discovered at once, the resulting overheating may crack the block or burst the radiator.

3. **EXCESSIVE WEAR DUE TO SAND.**—Sand is present in the air at all times and scored cylinders, badly worn main bearings, crankshaft journals, front wheel joints, distributors, etc., result from sand getting into working parts. Air filters must be inspected and cleaned much more frequently than in normal terrain. Cartridges on oil filters must be renewed after about one-fifth the distance usually permitted. Much sand will enter the crankcase and fuel lines when replenishing the oil or refueling unless great care is used during these operations. The driver must make an invariable habit of wiping all sand off the caps before removing and off the spouts of oil and gasoline containers before they are used. It may be necessary to make canvas boots to protect front wheel joints and distributors. Sand and dust will cause failure of instruments in panel if these are not carefully sealed. Scotch tape may be used for this purpose.

4. **VAPOR LOCKS.**—Vapor locks are frequent. The fuel lines and fuel pump should be located away from areas of great heat and should not be screened from the air from the fan. If vapor locks occur it may be necessary to insulate fuel lines and fuel pumps which cannot be relocated.

5. **ELECTRICAL DIFFICULTIES.**—The constant shock and vibration caused by the passage of rough ground frequently causes cable clips to shake loose and cables are broken or shorted. Frequent inspection of cable clips should be made and spring washers inserted under the nuts if possible. Voltage control units may cause trouble because of breaking of wire in shunt winding or sticking of regulator points. Drivers must be trained to watch the ammeter as carefully as any other instrument since overcharging, even when not sufficient to buckle the plates, always results in loss of battery water, most difficult to obtain in the desert. Drivers must be warned that the high salinity of water issued for drinking and for radiators forbids its use in batteries.

6. **LOADING.**—Carelessness in loading vehicles must be guarded against. Excessive breaking of springs has been a constant source of trouble in the vehicles used in the desert. The rough going is very hard on springs and they are quickly broken by overloading, improper distribution of load, or shifting of load while moving. Each vehicle commander must be fully instructed in proper load distribution and impressed with his responsibility in this matter.

7. **DRIVER MAINTENANCE.**—The importance of driver maintenance cannot be overemphasized. The necessity for dispersion makes supervision of drivers by officers and unit maintenance personnel very difficult in a terrain which subjects the vehicle to more abuse than is normally encountered anywhere else. The lack of water and the constant danger of hostile ground and air attack make vehicular failure a threat to the lives of all the personnel with the vehicles. The actual operation of a vehicle in this terrain requires tremendous physical exertion and concentration with resultant fatigue. Drivers and vehicle commanders must be impressed with the importance of taking advantage of every opportunity to inspect the vehicle, to follow prescribed maintenance methods without deviation, and to assure themselves at every halt, before anything else is done, that the vehicle is made ready to move again at a moment's notice.

APPENDIX II

DISTANT GROUND RECONNAISSANCE

1. **GENERAL.**—The great spaces involved in desert operations and the necessity to limit the number of troops used due to the difficulties of supply, particularly water supply, make the use of patrols for long-range reconnaissance an important factor for success. These patrols must be specially organized and equipped.

2. **OBJECT.**—Patrols for distant ground reconnaissance should be so organized and equipped that they can execute the following missions:

- a. Obtain military, geographical, and political information.
- b. Disseminate propaganda among native tribes and populations in distant parts of hostile territory.
- c. Raid hostile isolated desert posts and supply columns both for destruction and to cause the enemy to expend fuel, vehicles, and aircraft for protection against such raids.

3. **REQUIREMENTS.**—To accomplish the various missions given above, the requirements are—

a. The patrol must have sufficient cargo space and load capacity to carry the fuel, rations, and water necessary for extended operations away from supply dumps.

b. The patrol must be able to traverse every type of desert surface, including the great dune areas. Patrols should average daily runs of at least 150 miles over known routes and 100 miles in unknown and trackless terrain. Since it is inevitable that some vehicles will get stuck in soft ground or sand from time to time, particularly in unknown terrain, the number of vehicles must be limited in order to prevent these delays from unduly reducing the daily rate of travel.

c. The patrol must carry a gun of sufficient range to attack escorted enemy motorized columns at a distance beyond that of effective machine-gun fire; and should also carry a weapon capable of causing damage inside the mud-walled fort which is the usual form of desert fortification.

d. The patrol must be able to develop sufficient antiaircraft fire to keep hostile aircraft at a reasonable height.

e. In order to attain the required endurance (see *a* above), the number of men per vehicle must be reduced to the minimum needed to extricate the truck from soft ground and to develop the necessary fire power. This minimum is three men.

f. The patrol must be able to operate away from any known track or landmark and over unmapped country. This requires both means for accurate dead-reckoning navigation and for fixing position by astronomical means.

g. The patrol must have vehicles with sufficient speed to avoid combat with armored vehicles, must be able to rush steep (25°) slopes of sand dunes, and must be capable of quick maneuver.

4. ARMAMENT.—The following armament should fulfill the requirements given above:

1 37-mm gun, truck-mounted, for all-around fire.

1 81-mm mortar.

A proportion of caliber .50 machine guns (truck-mounted).

1 caliber .30 light machine gun (truck-mounted) for all vehicles not carrying 37-mm or caliber .50 weapons.

1 caliber .45 submachine gun for each vehicle driver. Such mines, explosives, and grenades as required for specific operations.

5. VEHICLES.—From the above it is apparent that some type of light cargo truck is required for such patrols. Armored vehicles have too high a gasoline consumption to have the endurance required. Heavy trucks require increased cargo in rations, water, and gasoline. (See par. 3e.)

6. LOAD.—The number of trucks in a patrol is dependent on the essential load per individual truck, the load to be distributed throughout the patrol, based on requirements, radius, and duration of the operation. The table in *a* below shows a method for determining the number of vehicles necessary for operations for a period of 14 days over a distance of 1,000 miles:

BASIC FIELD MANUAL

	Pounds
a. Essential load common to all vehicles.	
Fuel for 1,000 miles at 8 mph (125) gallons) -----	1, 250
Oil for 1,000 miles (5 gallons) -----	50
Grease for 1,000 miles -----	5
Rations (C) for 14 days for 3 men at 5.1 pounds -----	215
Emergency rations (D) for 3 days for 3 men at 1.0 pound -----	9
Water for 14 days for 3 men at 1½ gallons per man per day -----	550
2 men with equipment (driver not included in pay load) -----	400
Minimum armament and ammunition for one vehicle:	
1 caliber .30 machine gun, light -----	42
1 caliber .45 submachine gun -----	19
2,000 rounds caliber .30 ammunition -----	152
1,000 rounds caliber .45 ammunition -----	55
Total -----	2, 747

Total indicates truck of at least 1½ tons required____ 3,000
—2,747

Surplus 253

b. Armament and ammunition for patrol as a unit.

1	37-mm gun, truck-mounted, with mount	500
200	rounds 37-mm ammunition	700
1	81-mm mortar with mount	136
100	rounds 81-mm ammunition (L)	967

Total 2,303

c. $2,303 \div 253 = 9+$, or 10 $1\frac{1}{2}$ -ton vehicles required. This will give a small margin for extra fuel for an eleventh light pilot car, $\frac{1}{4}$ -ton truck, reconnaissance, which would not be self-supporting, permit substitution of a caliber .50 machine gun for caliber .30 on 3 trucks, and allow for radio equipment and spare parts.

d. While overloading must be guarded against, the daily lightening of each truck load, based on a run of 150 miles, should be considered. This amounts to 230 pounds per truck in fuel, water, and rations consumed and may permit some

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overload for specific operations, particularly when the first few days' travel will traverse previously reconnoitered routes in the vicinity of the base.

7. ORGANIZATION.—A suggested organization, using the vehicles and armament given in paragraphs 4 and 5 above, is a patrol of 2 officers and 30 enlisted men, using 10 1½-ton trucks and 1 ¼-ton reconnaissance truck. This can be organized into 4 troops, each of which, being self-supporting, would be capable of independent action. The patrol can also be split into halves, each commanded by an officer and capable of its own navigation.

Officers, 2:

1 captain, commanding patrol.

1 lieutenant, second in command.

Enlisted men, 30:

1 sergeant, acting first sergeant.

2 corporals, navigators.

2 corporals, gunners.

3 radio operators.

11 drivers.

8 gunners, machine gun.

1 gunner, 37-mm.

2 mechanics, automobile.

All personnel must be able to drive and to handle machine guns.

RIGHT HALF PATROL

<i>Vehicles</i>	<i>Personnel</i>	<i>Armament, etc.</i>
A (Hq) Troop:		
No. 1, ¼-ton---	1 captain, commanding. 1 driver.	1 cal. .45 submachine gun.
No. 2, 1½-ton--	1 corporal, navigator. 1 radio operator. 1 driver.	1 cal. .30 machine gun. 1 cal. .45 submachine gun. 1 radio.
B Troop:		
No. 3, 1½-ton-	1 corporal, gunner, in command of troop. 1 gunner, machine gun. 1 driver.	1 81-mm mortar. 1 cal. .30 machine gun. 1 cal. .45 submachine gun.
No. 4, 1½-ton-	1 gunner, machine gun. 1 asst. radio operator. 1 driver.	1 cal. .50 machine gun. 1 cal. .45 submachine gun.
No. 5, 1½-ton-	1 mechanic, automobile. 1 gunner, machine gun. 1 driver.	1 cal. .30 machine gun. 1 cal. .45 submachine gun.

LEFT HALF PATROL

<i>Vehicles</i>	<i>Personnel</i>	<i>Armament, etc.</i>
C Troop:		
No. 6, 1½-ton	1 sergeant in command of troop.	1 cal. .30 machine gun.
	1 gunner, machine gun.	1 cal. .45 submachine gun.
	1 driver.	
No. 7, 1½-ton	1 corporal, gunner, 37-mm.	1 37-mm gun.
	1 gunner, 37-mm.	1 cal. .45 submachine gun.
	1 driver.	
No. 8, 1½-ton	1 radio operator.	1 cal. .30 machine gun.
	1 gunner, machine gun.	1 cal. .45 submachine gun.
	1 driver.	1 radio.
D Troop:		
No. 9, 1½-ton	1 corporal navigator.	1 cal. .30 machine gun.
	1 gunner, machine gun.	1 cal. .45 submachine gun.
	1 driver.	
No. 10, 1½-ton	1 mechanic, automobile.	1 cal. .50 machine gun.
	1 gunner, machine gun.	1 cal. .45 submachine gun.
	1 driver.	
No. 11, 1½-ton	1 officer, second in command.	1 cal. .30 machine gun.
	1 gunner, machine gun.	1 cal. .45 submachine gun.
	1 driver.	

Ammunition for 37-mm gun to be distributed in left half patrol; for 81-mm mortar, in right half patrol.

8. PERSONNEL.—*a.* Officers must be carefully selected for this type of duty. Those who have had experience in desert terrain would be ideal, but it is doubtful that many such will be found in our forces. An officer who has had considerable experience in hunting and fishing trips away from civilized communities, or one who has had experience in small boat cruising should be suitable for desert patrols.

b. Enlisted men selected for this work must also be especially picked, if possible from volunteers. They must be resourceful, alert, intelligent, and possessed of a high sense of responsibility. Every man must be a skilled driver, with sufficient experience to have developed an eye for desert surfaces, and an expert with the machine gun and submachine gun. At least two men should have sufficient medical training to dress wounds and administer narcotics in emergencies.

9. TRAINING.—Assuming that the personnel of a patrol have the technical training required, the only real training for the patrol work will be gained by journeys in the desert.

The desert is the principal enemy to be conquered and contact with it will be constant. Drill will be required to develop skill in adopting and changing formations and each member of the patrol must know thoroughly the formations to be used. When the patrol has made a trip of a thousand miles across unmapped, trackless terrain it will be ready to operate against an enemy in his own desert territory.

10. COMMUNICATIONS.—The patrol must be equipped with radio, but the use of radio communication must be limited to the minimum. Within the patrol, communication should normally be by flag signals. Pyrotechnic signals must be available but used only in emergency. Radio messages from the patrol's base or other sources should be sent on a time schedule and acknowledged only in an emergency.

APPENDIX III

ORGANIZATION

1. **GENERAL.**—The peculiar conditions which exist in the desert and a study of the operations in desert terrain conducted during the present war indicate that the standard armored divisional organization may not permit maximum use of the speed and mobility of the modern tank. The German forces have, according to observer's reports, increased the number of highly mobile supporting weapons in proportion to the number of tanks in a task force. British failure to do this may have been one of the reasons for the high tank casualties which the forces have suffered.

2. **TASK FORCE.**—The following task force has been suggested by observers as one which would prove more satisfactory for operations under the conditions which exist in the desert terrain of Africa:

Command----	Headquarters company, with 6 light tanks. Headquarters protection company, with 20 tanks, 10 armored cars (for command post and train protection).
Reconnaissance. }	Armored car regiment of 3 squadrons.
Armored-----	Regiment of 3 battalions of 50 tanks each.
Support-----	Regiment Field Artillery (at least 50 percent self-propelled).
(Under 1 support com- mander.) }	Regiment antitank (100 percent self-propelled) (4 companies).
	Regiment antiaircraft (dual purpose weapons).
	Battalion motorized Infantry, 4 companies.
	Company motorized engineers with 10 light tanks.
Maintenance--	Ordnance company, with 9 tanks for battle-field recovery.
Trains-----	Vehicles and organization to permit one refill of ammunition and fuel always to be in close proximity to combat units, and rear echelon to hold 1 day's supply fuel, rations, and water and 1 unit of fire for all weapons mobile at all times.

APPENDIX IV

SANITATION AND FIRST AID

1. **GENERAL.**—The health of troops living and operating in the desert itself has been generally better than is expected in more normal terrain. Except during actual combat operations, however, the bulk of the troops will normally not be in the desert proper but will be in areas closely adjacent to it. In such areas native populations predominate, sanitation is not generally good, and various diseases are prevalent.

2. **DESERT.**—Troops from temperate zones must be allowed a sufficient period to become acclimated to the high temperatures which prevail in the desert. To avoid excessive casualties from sunstroke and heat prostration all personnel must be thoroughly trained in preventive measures and in the symptoms and first-aid measures to be taken. Sand fly fever is prevalent and, while it is not fatal unless complications arise, it is definitely incapacitating to the victim, usually for several days.

3. **AREAS ADJACENT TO DESERT.**—*a. Malaria.*—Malaria is generally present in nearly all areas adjacent to deserts and is found in most oases. In much of the mountainous desert areas in the Near East it is quite prevalent. In coastal regions bordering the Western Sahara Desert a particularly virulent type of malaria prevails. While long-range control, that is, drainage, etc., would be desirable, it will generally be impossible because of the time element and the indifference of native inhabitants. Segregation of troop quarters, use of mosquito bars, sleeping boots and gloves, daily early morning spraying of native habitations, and a regular issue of quinine will prevent excessive losses from this disease.

b. Dysentery.—Dysentery has been very prevalent among the troops now in and adjacent to the desert. In those areas in which sanitary regulations have been strictly enforced there have been no epidemics. The great dispersion which must be practiced in such terrain makes control of waste

disposal very difficult. It can be controlled, however, if the importance is made apparent to every member of the command and infractions of regulations are punished with the severity which their seriousness warrants.

c. Parasites.—Many parasites are found in these areas. *Bilharzia*, *cercaria*, and other blood parasites have been contracted by troops while bathing. The importance of care in the water used for bathing must be impressed on the troops, and the sanitary regulations in regard to bathing must be strictly enforced. Body lice are prevalent among the natives, and typhus epidemics have occurred in the past in all settlements near possible desert theaters of operations.

APPENDIX V

SUPPLY

1. **REGIMENTAL SUPPLY METHOD.**—The difficulties of supply in desert operations are discussed in section X. The following method has been successfully used to supply a force equivalent to an armored regiment (U. S.) during combat in desert terrain:

a. Division of transportation.—The combat trains of a battalion are divided into two echelons, B-1 and B-2.

(1) The B-1 echelon of each armored battalion consists of maintenance crews and gasoline and ammunition trucks with the following loads:

- 1 refill of fuel for tanks.

- $\frac{1}{2}$ refill of fuel for other vehicles.

- 1 refill of ammunition for both tanks and other vehicles.

(2) The B-2 echelon of each armored battalion consists of unit maintenance equipment, rations, water, baggage, gasoline, and ammunition vehicles with the following loads:

- 1 refill of fuel for tanks.

- $\frac{1}{2}$ refill of fuel for other vehicles.

- $\frac{1}{2}$ refill of ammunition for both tanks and other vehicles.

- 1 day's rations and water.

B-1 and B-2 gasoline and ammunition vehicles are interchangeable and as the load in B-1 is emptied it reverts to B-2 and full vehicles from B-2 move forward and become B-1. This process is continuous.

(3) Regimental B echelon consists of all unit B-2 echelons plus regimental headquarters and service company B echelons (regimental trains less B-1 echelons).

b. Method of handling transportation.—(1) The consolidated B-1 echelons move under control of the regimental assistant S-4, who is in constant radio communication with S-4 at regimental headquarters. The B-1 echelons follow closely behind the tanks, not more than 10 miles from the front, so that a quick refill of ammunition and fuel is available.

(2) Rations, water, other supplies and maintenance equipment with the B-2 echelons move up to the units each evening, preferably before dark. Ammunition and fuel is moved up only when required.

(3) The unit B-2 echelons and the regimental B echelons move and bivouac together except when the unit B-2 echelons move up to their units (see (2) above).

(4) During the approach march the maintenance crews and extra fuel trucks (from B-2 echelon or the division trains) may move with the tanks.

c. Command.—(1) B-1 echelons under command of assistant S-4.

(2) B-2 echelons and regimental B echelons under command of service company commander.

d. Method of refilling with fuel and ammunition.—When battalions require either fuel or ammunition they inform regimental headquarters, stating their location. S-4 orders up the necessary loads from the B echelons (normally B-1) and immediately calls the division trains for the necessary refill for the regimental B echelon. When a unit uses only a small part of the refill, the vehicles return to the regimental B echelon and are fully loaded.

e. Supplies and water.—(1) *Rations.*—Three days' rations are carried on all vehicles for personnel who normally travel in the vehicle. These are for emergency use only. An additional emergency ration (D ration) is carried by each man.

(2) *Gasoline.*—A vehicle reserve of two 5-gallon cans of gasoline is carried on each vehicle for emergency use.

(3) *Water.*—(a) One and one-fifth U. S. gallons of water per man are delivered daily to B echelons by the division trains. It is delivered in 15-, 5-, and 2½-gallon containers. Units, when replenished, exchange empty containers of equivalent capacities to those drawn.

(b) The three forms of water transport are—

1. *Vehicle reserve.*—Each vehicle carries reserve water, in containers, sufficient to allow its crew 1½ U. S. gallons per day for three days.

2. *Unit reserve.*—One and one-fifth gallons per man carried in water trucks and in drums.

3. *Unit supply*.—Sufficient containers for the daily water ration from division trains, (a) above, are carried in B echelon vehicles. The unit reserve water carried in water trucks and drums and the vehicle reserve carried in small containers are constantly changed over to insure that water in vehicle and unit reserves is fresh.

f. System of replenishment.—(1) The regiment has assigned to it, in the division trains, a truck company for transporting all supplies. This company is divided into three sections, fuel and ammunition, water, and rations.

(2) This company replenishes the regiment near the regimental B echelon bivouac.

(3) Upon arrival at the replenishment area the truck company commander meets the regimental service company commander and S-4's representative, who informs him of the exact amount of fuel, lubricants, and ammunition required by the regiment, based on information furnished him previously by the battalion S-4's.

(4) The truck company commander directs the proper amounts to be unloaded on the ground. While this is taking place the battalion S-4's turn over the empty water containers and check their rations on the ground. Rations and water are unloaded from truck company prior to arrival of B echelon. When water and rations are checked, the battalion S-4's report the fact to the regimental service company commander. When the last battalion S-4 reports, the truck company moves out and the B echelon trucks move in and pick up the supplies left on the ground. With training, the whole operation requires about 1 hour. Dispersion of at least 100 yards between vehicles is usually maintained.

(5) Loads are not broken on the ground, but are collected and broken in the B echelon bivouac area.

(6) The formation in which the supply sections arrive is constant, that is, ration trucks in front and water trucks in rear, in regimental alphabetical order from left to right as the sections reach the replenishment area.

(7) Flags are used by unit supply officers for quick recognition by drivers of various dumps of the different sections.

2. **FIELD SUPPLY DEPOT**.—*a*. This corresponds to a division truckhead and is stocked with all classes of supplies. Site is

selected by division and the depot is stocked and operated by corps. Effort is made to keep it within 50 miles of the division. In actual practice it has been from 0 to 200 miles distant. The principal difficulties encountered were due to—

(1) Lack of trained personnel for the operation of depots. Since dispersion is great, issue and loading are difficult to supervise and require thorough training of all individuals in depot personnel.

(2) Time allowed for stocking was frequently insufficient because of inexperience in desert conditions. Sand and dust storms, loss of direction, and loss of time in loading and unloading all added to normal time allowance.

(3) Division transport used to carry unexpended stocks when depot moved forward, which resulted in break-down of transport.

b. Successful operation of this method of supply demands—

(1) The site for depot be selected by the division.

(2) Establishment, issue, and loading be accomplished by depot personnel.

(3) Sufficient depot personnel be available to operate one depot and at the same time to establish a new one.

(4) Close cooperation and constant communication between division G-4 and the field supply depot commander.

3. DIFFICULTIES ENCOUNTERED IN SUPPLY OF DIVISION.—a. *Rations*.—Failure to check loads at field supply depot to insure that all commodities in the daily ration were in the correct proportion resulted in failure to feed troops properly and in wastage.

b. *Water*¹.—(1) Rapidity with which water tank trucks became unserviceable made supply difficult.

(2) The long distances over which water had to be carried resulted eventually in reduction of daily ration.

(3) The rapid wastage of unit water containers made distribution difficult.

¹ Accumulation of very large water stocks in the field supply depot is almost impossible. Temporary storage tanks of canvas have been used but the loss by evaporation and seepage is large. One armored division (U. S. type) requires 3,225 5-gallon containers for 1 day's water supply. For normal supply this number will have to be filled each day at the field supply depot and loaded in vehicles three times in one 24-hour period (division trains, B echelon, and combat vehicles). Thirty-three 2½-ton trucks of the division train will be required to move these containers to the replenishment areas.

4. **GASOLINE, OIL, AND OTHER LUBRICANTS.**—The problem of transportation is the chief difficulty in these supplies. The necessity for dispersion precludes the use of tank trucks forward of the field supply depot. To protect against air attack tank trucks must be camouflaged even in rear areas, and fuel supplies in the field supply depots must be dispersed and their nature disguised. A certain percentage of vehicles must be kept loaded in division trains to provide for the loss of unit B echelon vehicles.

5. **AMMUNITION.**—A large ammunition supply must be kept mobile. Ammunition expenditures have been unusually high in desert operations, and the rapid movement of the combat forces has resulted in the loss of much stacked ammunition in the forward areas. Ammunition in the field supply depots must be carefully stored to protect it from the sun and sand. All German ammunition except that for small arms is specially packed for desert use.

6. **DAILY REPLENISHMENT.**—*a.* Replenishment of supplies of combat troops must be early and punctual. Effort should be made to have the B echelons arrive at unit bivouacs at dark. Careful coordination is required to permit issue of supplies to combat units, the return of B echelon to the replenishing area, transfer of loads from the division truck company to B echelon vehicles, break-down of loads in the B echelon bivouac, and return and refill of division trains at the field supply depot. An average rate of march of 10 miles an hour is the maximum that can be expected of supply vehicles. The replenishment schedule must be strictly adhered to except in a grave emergency.

b. The use of a truck company, subdivided into sections serving units in all supplies, is a necessity in the desert. Maintenance of supplies by separate companies for ammunition, fuel, and rations would increase greatly the protective forces required as well as navigational difficulties. The use of gasoline and ammunition refilling points has been found impracticable because of the danger of hostile raids in the forward areas and the inability of single vehicles and small groups to navigate in desert terrain. All supply vehicles must move in a group with a navigator, or under the direction of a guide.

7. **SPARE PARTS.**—The problem of providing sufficient spare parts and maintaining vehicles has not been satisfactorily solved in the desert. An increase in the number of vehicles to permit greater quantities to be carried in the B echelons and the provision of vehicles at the field supply depot to bring forward such supplies in an emergency may offer a solution.

8. **RECOVERY.**—Recovery must commence on the battlefield and continue until vehicles are repaired on the spot or evacuated to a protected area. Plans must be made to provide protection for recovery crews in the event the tank elements leave the field for further maneuver against or in pursuit of the enemy.

9. **REPLACEMENT.**—There must be a reserve not only of combat vehicles but of supply vehicles as well. Vehicular casualties are particularly high in desert operations. To provide for efficient replacement highly trained personnel, particularly tank drivers, must be held available to deliver vehicles of all classes to units in the combat area. Personnel replacements for armored units may be used to bring vehicular replacements forward. However, up to the present, the vehicular casualties have been greater than casualties among personnel, and time will be saved if sufficient tank drivers are available in rear areas to deliver tanks to the crews rather than sending the crews back for tank replacements.

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